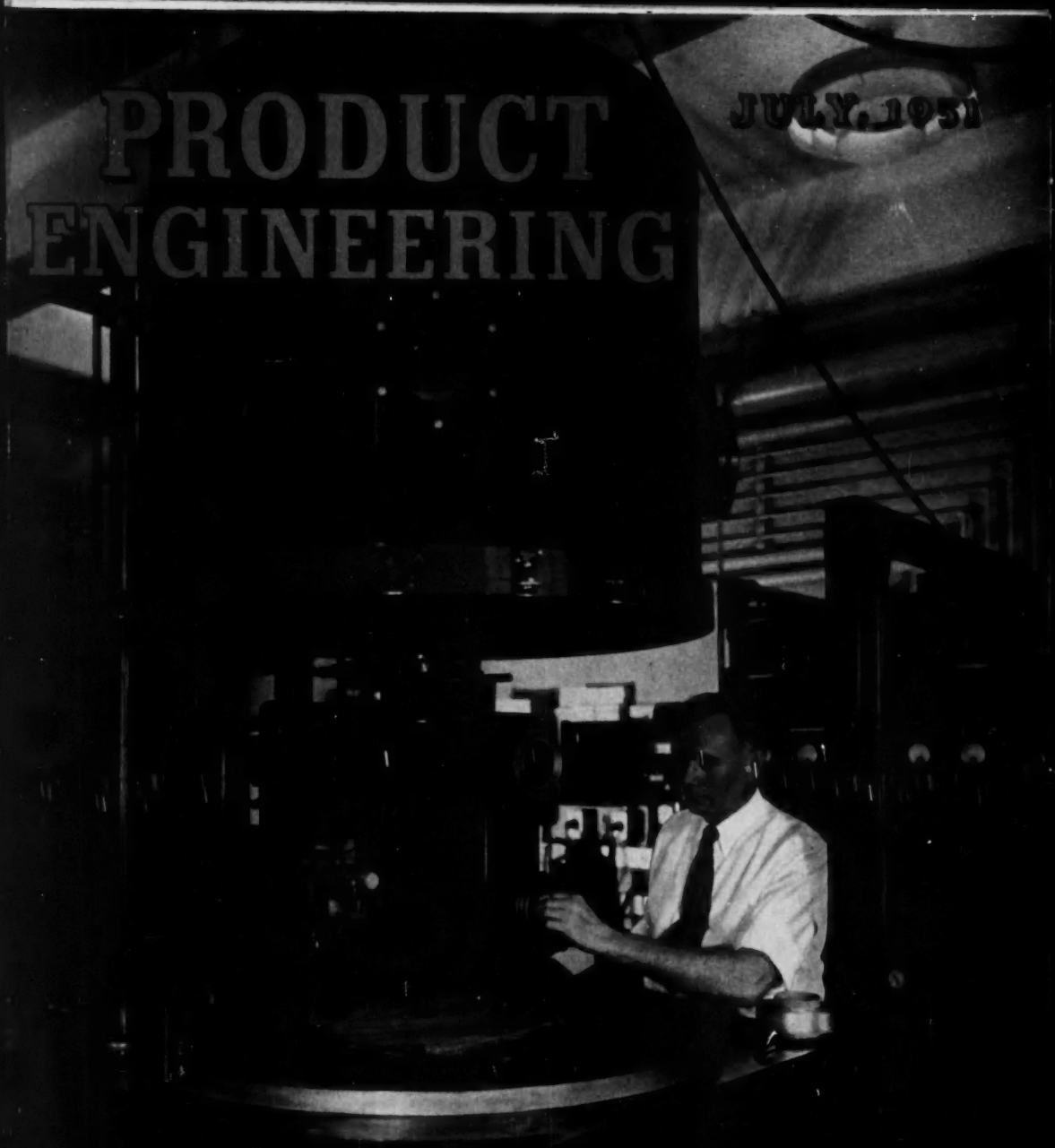
PRODUCT ENGINEERING

JULY, 1951

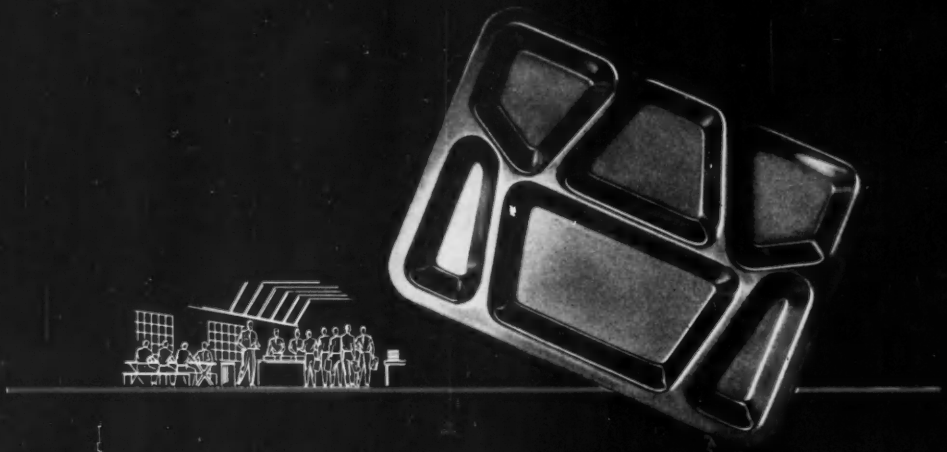


CONDENSER MACHINE

IN THIS ISSUE—Metallic Coatings • Economical Gasketing • Stresses in Disks • Synchronizing Hydraulic Cylinders • Design Against Corrosion

A McGRAW-HILL PUBLICATION
FIVE DOLLARS A YEAR

Popular Pattern in Modern Dinnerware . . .



SHARON* STAINLESS and RUST-RESISTANT ALLOYS ADD LIFE TO MILITARY MESS GEAR

An army travels on its stomach. Modern military leaders know the truth to that remark. Sanitation is of utmost importance. The stainless mess trays are extremely easy to clean, and they can absorb punishment. The field kits are light in weight, tough and resistant to rust even under the corrosive conditions found on the salt water washed islands of the Pacific.

The expansion of our fighting force calls for additional supplies, and once again large tonnages of Sharon stainless and rust resistant alloys are being allocated for hundreds of military requirements — including the health-protecting mess gear now adopted as standard equipment.

*Specialists in STAINLESS, ALLOY, COLD ROLLED and COATED Strip Steels.

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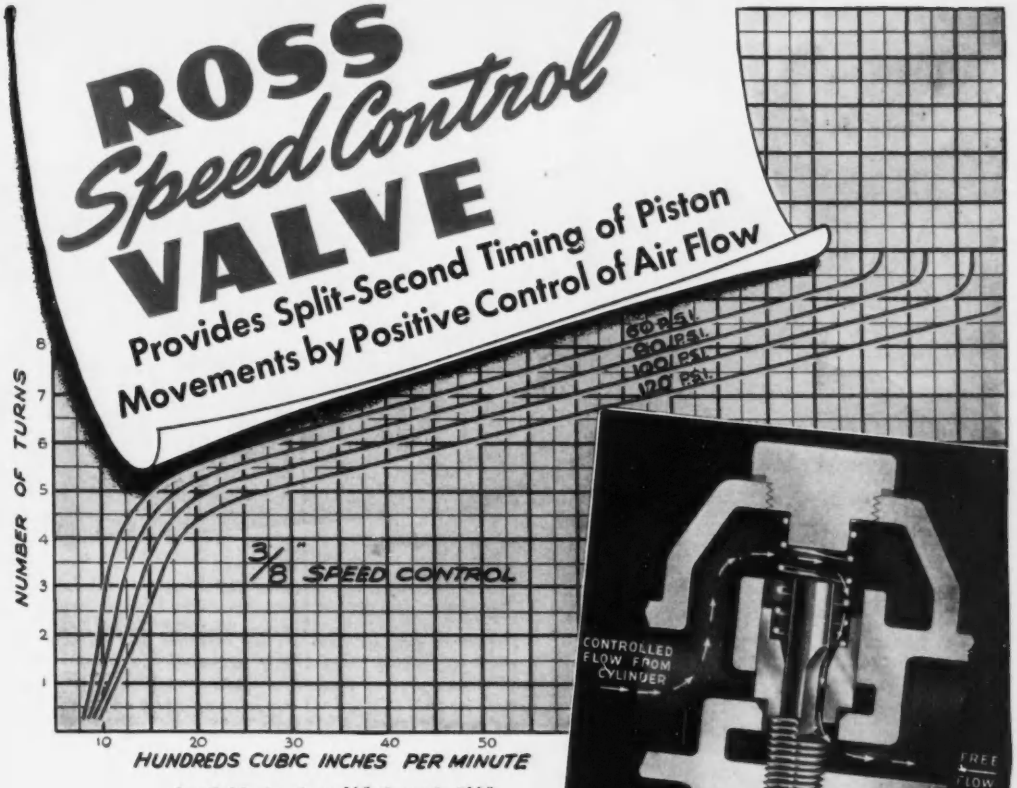
Sharon, Pennsylvania

DISTRICT SALES OFFICES: CHICAGO, ILL. CINCINNATI, O. CLEVELAND, O. DAYTON, O. DETROIT, MICH. INDIANAPOLIS, IND. MILWAUKEE, WIS. NEW YORK, N. Y. PHILADELPHIA, PENNA. ROCHESTER, N. Y. LOS ANGELES, CALIF. SAN FRANCISCO, CALIF. MONTREAL, QUE. TORONTO, ONT.

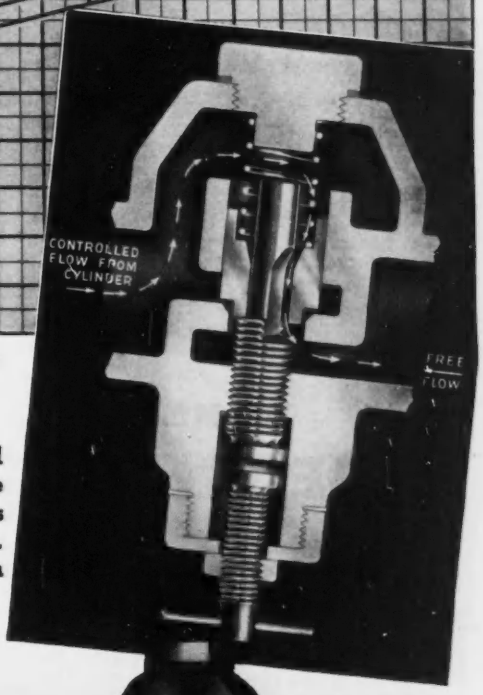
SHARONSTEEL

ROSS *Speed Control* VALVE

Provides Split-Second Timing of Piston Movements by Positive Control of Air Flow



Available in sizes ¼" through 1¼"



With air flow regulated by screw action, changes in volume take place with constant progression—not a series of "steps"—but with micrometer accuracy. Control of the air flow is absolute—from zero to maximum.

Simple—dependable—rugged. Only two moving parts—stem and poppet.

Typical thermometer and barometer desk set made by Standard Thermometer, Inc., 952 Dorchester Ave., Boston 25, Mass. Standard's instruments are not only sold to government, industry and over the counter, but many are also imprinted with company names and become valued gifts to top executives of important customers.

Punching spoke holes in brass cups which have been drawn, cut, and passed by Inspection.

TO MEASURE TIME AND WEATHER

BEGIN WITH THE BRASS

● Standard Thermometer, Inc., is a well-known maker of thermometers, barometers, hygrometers, and clocks, for outdoor, desk, and industrial use. Naturally, brass is an important item in these instruments, being used for cases because of its golden beauty and for operating parts because of its reliable physical characteristics, including corrosion resistance.

Fabrication methods include stamping and drawing of cases and bezels. The company is an old and experienced one, dating back to 1885, and has been a Revere customer since that time. Recently it began to experience certain fabrication difficulties. When Revere heard about them, the Technical Advisory Service was asked to look into the matter. The brass being used was analyzed, and factory tools and methods studied. An elaborate 17-page report was prepared, including photographs of micro-sections to show the grain structure of various samples, and detailed recommendations were made. In general, it was found that such things as puckers, orange peel, and flare were due to a combination of factors, including composition of the brass, its temper, the dies, and the lubricant used on them. Standards were set up for metal specification and though Revere does not design dies, suggestions were made for the consideration of the designers.

After digesting the report and putting the recommendations to the proof, Standard wrote: "We are extremely grateful for this information, and it represents a splendid job and one of great value to us."

Perhaps Revere can work with you too on such matters as specification, fabrication, ideas to save precious metal. Our collaboration is freely given.

REVERE 150th YEAR OF SERVICE TO AMERICA

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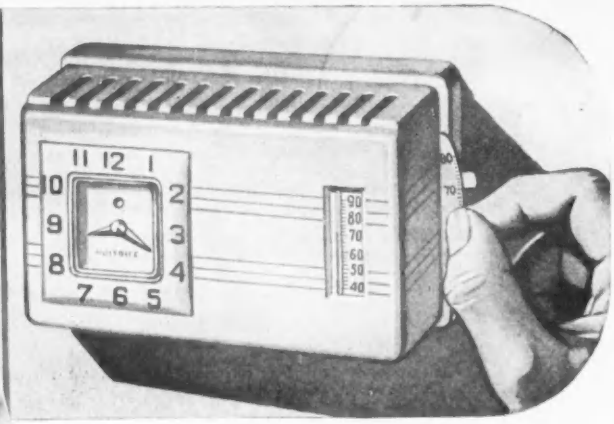
Result Beyond Expectation!



Mallory Creative Research

Develops Low-Cost Technique For Platinum-Tipped Contact

New time and money saving methods for meeting customer contact specifications result from continuing research and development by Mallory.

Typical is the application of Mallory metallurgical and welding experience to the problem of attaching and forming the platinum tip on a contact screw used in home thermostats. Mallory tackled the problem of reducing the high cost involved . . . and came up with a new weldable material for the screw, a way to weld the tip in place more securely, and a method for forming the tip to proper contour. Savings on machining and waste platinum were immediately passed on to the customer.

That's result beyond expectation!

Mallory contact know-how is at your disposal. What Mallory has done for others can be done for you.

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Platinum is ideal for electrical contacts where low resistance must be maintained for long periods of time. However, pure platinum lacks hardness. Mallory platinum alloys overcome this by the use of such hardening agents as iridium, ruthenium and palladium. Mallory is fully qualified to recommend the best contact material for your design. Write today.

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Highlights

In this summary of technical developments, space restrictions do not allow giving complete details. Further information relating to any item can be obtained by writing to the Editor of Product Engineering.

METALLIC MATERIALS

MANGANESE DIOXIDE should be off the critical list, now that Signal Corps engineers have come up with a synthasized material. This development will be of primary interest to dry cell battery makers.

CREEP TESTS on various aluminum alloys, including an extruded bar of 25S, reveal important data regarding elevated temperature applications. The difference between creep resistance of various alloys at 100 C tend to disappear at 300 C, thus indicating that the 0.1 percent proof stress (yield strength) at any given temperature is not a true measure of creep strength at that temperature.

SILVER CLAD STEEL is working out well in some applications where hard-to-get copper base alloys are generally used. Amount of the structurally bonded silver is calculated to match the electrical conductivity and corrosion-resistance of copper bearing materials in electrical contacts and anti-friction bearing cages.

IRON-SILICON ALLOY intended for use in wound-type transformers and reactors operated at 400 cycles handles inductions 20 percent higher than most nickel-iron alloys. Made by Armco Steel, the thin electrical steel has a minimum permeability at 18 kilogausses of 1,800. Volume resistivity is 47 microhm-cm or 282 ohms/mil ft and lamination factor is 95 percent solid.

TINY MAGNETS the size of a pencil eraser have 24 times the lifting power of a similar sized Alnico-5 magnet, and eight times more resistance to demagnetization. Composed of cobalt and platinum, GE's new material is ductile to the point where it can be drawn into wire or thin sheets.

EXTRA-FINE aluminum pigment is reported to take on a brilliance that is comparable to a chrome finish. Auto hardware is a possible use.

GRAIN REFINING is not the only role played by zirconium in magnesium-base casting alloys. It helps distribute heat through the mold and thus reduces micro-porosity in the finished casting. Section sensitivity is also reduced so that test-bar results are comparable to physicals made on machined bars.

MATERIALS CONSERVATION is being applied right down the line at the Bell Telephone Labs. Copper-clad steel is taking the place of solid copper and some wire gages are 24 instead of 22. Cobalt for permanent magnets in instruments is being replaced by an alloy of 5.0 percent chromium, 21 percent molybdenum and the balance iron.

NONMETALLIC MATERIALS

COLD-SETTING RESIN for patching rubber linings and coatings is reported to have corrosion and heat resistance properties superior to those of rubber. Flexibility is sufficient for most services except on belts, and shrinkage is about one-tenth of one percent. A synthetic rubber primer is used when the resin is bonded to steel.

EXHAUST HEADERS coated inside and out with NBS ceramic Type A417 have little or no evidence of corrosion after long periods of exposure. These 0.045-in. thick, low carbon steel assemblies completed 1,234 hr of service on aircraft engines without any reduction in gage thickness.

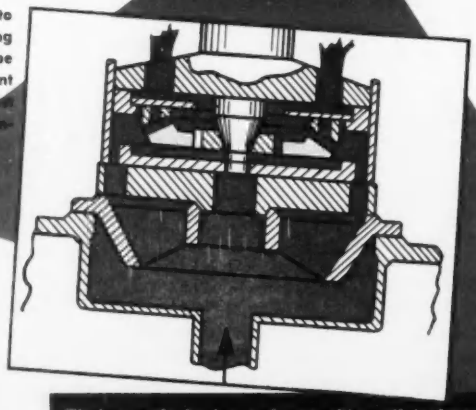
HAE COATING FOR MAGNESIUM is applied electrolytically as a film 0.001 to 0.0015 in. thick. Hard enough to scratch glass or polish Rc65 steel, the wax-covered coating has survived 4,500 hr of salt spray without corroding. During heat-tests, magnesium panels have melted away from the undamaged coating.

TRANSLUCENT DRAWING PAPER coated with the same emulsion used on Eastman's Autopositive paper is now available. Drawing changes are simple, as lines can be quickly erased when

(continued on page 7)

ROUND AND TRUE *with* DISTORTION-FREE QUENCHING

When hardening of metal parts is required, the first thought is to prevent distortion. Gleason quenching presses hold parts being quenched between dies which maintain the original shape throughout a metallurgically correct oil flow. This die equipment conforms to the actual shape of the part, and does not obstruct free oil flow over and around the part. It maintains true concentric shape of the part during the entire quench.



Timing cycle begins and quenching oil is forced into quenching chamber and around gear. Quantity and time cycle are under positive control during complete quenching cycle.

In the Gleason No. 36 Quenching Press parts up to 36" may be hardened. Among the many advantages which the 36" Press provides are:

- Controlled quenching at faster and safer production
- Simplified set-ups
- Metallurgically correct oil flow
- Safer loading
- Quenching without distortion

Write for literature. Send in prints of parts to be quenched for our recommendations.

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moistened. Adaptable to all daylight equipment, paper shows black lines from either side.

CHEMICAL PREPARATION of aluminum, magnesium and ferrous metal surfaces prior to finish coating is not needed, say the makers of Ferrotite resin primer. Product can be used under lacquers and most synthetic coatings. After curing for 20 min at 325 F, primer is resistant to acetone.

HYDRAZINE, a long-known but little-used chemical, is coming into its own as a soldering flux. Suitable for joining most of the commonly-used metals, the flux leaves no corrosive residues. Automobile radiators are one application where the material does an outstanding job.

HEAT RESISTANT Kel-F is now being produced in larger forms and special shapes: Extruded tubes of 2-in. dia and 0.020-in. thickness; sheets up to 1/4 in. thick; extruded rods of 7/16-in. dia; and molded rods of 1 1/2-in. diameter.

COMPONENTS

PERIODIC REVERSE electroplating may solve the auto makers' problem of a substitute for chrome plate on bumpers. Westinghouse engineers find a 0.001-in. copper film plus a thin plating of nickel both deposited by this method, result in a shiny finish that does not require polishing.

ADDITIONAL ELECTRICAL EQUIPMENT required in late-model aircraft is posing a serious weight problem. Designers are therefore putting more emphasis on the use of press-forged integrally stiffened structures to save weight in the fuselage and wings. Bigger presses will be needed to do the job.

SIMULTANEOUS PLATING of tin and nickel has been announced by the Tin Research Institute, Deposited in a ratio of two parts tin to one part of nickel, the combination has a pinkish color, a Brinell hardness of 700 and high corrosion resistance. Dual deposit cannot be plated on zinc-plated die castings that are first copper plated or aluminum castings after preplating with nickel.

SOLDERING of metal to glass, ceramics and carbon is the subject of exhaustive studies at GE. Glass and metal are coated with titanium hydride and soft solder placed on the coatings. Parts are then heated at 900 F in a vacuum. As the hydride decomposes, the molten solder bonds to the coated glass and metal. Thermal stresses between the two members are taken up by the solder.

HYDROGEN-FREE OZONE of high concentration is obtained by the electrolysis of perchloric acid in an improved process. A low-temperature electrolyte and a refrigerated anode are used, resulting in large yields and high energy efficiencies. Economical production of liquid rocket fuels is ultimate objective.

FATIGUE LIFE of 24ST sheet can be improved by pre-stressing the material for a limited number of cycles. Pre-stressing at 20,000 psi for 2,000 cycles results in an increase in fatigue life of 400 percent, while stressing for 20 million cycles causes an increase of only 33 percent. Tests were conducted at NBS in Washington.

IN CASES where it becomes necessary to weld brass or copper to aluminum tubing, the joints can be covered with vulcanized or synthetic rubber to prevent contact with a corrosive medium at the point of greatest electrolytic activity. Other methods of preventing galvanic corrosion are the use of sealing materials and primers.

PROCESSES

TEST-POINT JACK of small, compact design is becoming popular in wide variety of electrical equipment, both industrial and military. Of 3/8-in. diameter and one-inch length, assembly has a threaded insulating sleeve which houses a beryllium copper spring contact. Principle use is for in-operation voltage checks on instruments.

THREE SAFEGUARDS against thermal shock are built into Expandohm edgewound resistors. Core bar is coupled to terminals by rivets that "float" in slots; channels in the porcelains are widened at each end to give "play" to the core; and bar itself has stiffeners that confine flexing to the ends.

FILTER BLOCKS made up of molded cellulose fibers are reported to have the highest dirt-retention capacity of any known filtering medium. A bonding agent is added to the fibers which are then pressed and thermally stabilized to final

(continued on page 9)

Another new development using

B. F. Goodrich Chemical Company ***raw materials***

cutting block that cuts costs, too!

"Cut Rite Bloc" made by Rubber Engineering and Chemical Co., Lake Zurich, Ill.

HERE'S another success story that may help you—that shows how Hycar rubber improves products while it cuts costs.

The picture here shows a laminated cutting block made with a Hycar rubber compound. And what a difference it makes, compared to ordinary blocks. With formerly-used blocks, leather, rubber, cloth and other materials are frequently soiled by sawdust or discoloration.

This problem—and others—went by the boards when the Hycar-made block was developed. Cutting noise is greatly reduced. Dies remain sharp longer. There's uniform cutting efficiency in any weather. The block is good for millions of cuts. The wear-down in normal service is approximately ¼" per year.

It's another score in the long list of Hycar-helped successes. For Hycar is so versatile that it resists heat and cold, water, weather and wear, gas, oil, chemicals and more damaging conditions.

Hycar may answer your problems—may help you improve or develop a product. Demand now exceeds supply, but limited quantities are available for experimental work. For helpful technical advice and information, please write Dept. HL-4, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco.

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See Sweet's File for Product Designers, Materials Section, for further data on Hycar GEON polyvinyl materials
HYCAR American rubber • GOOD-RITE chemicals and plasticizers • HARMON organic colors

Need extreme temperature resistance? Hycar has it—plus abrasion resistance and more advantages.

Hycar American Rubber

dimensions. Resulting "cartridges" are then ready for use in standard oil filter housings.

SURGE DAMPERS for high pressure hydraulic systems are compact and easily adapted to most all circuits. The makers report that these valves prevent shock from occurring rather than simply absorb hydraulic surge and consequent shock. Units do not upset circuit operation.

PICTURE TUBE for television sets operates on an electrostatic focusing principle instead of electromagnetically. Significant design feature is that no cobalt or copper is required in the production of the assembly.

TINY POTENTIOMETER of drum type with radial terminal screws is 1 1/8 in. in dia and 2 in. long, including ball-bearing-mounted shaft. Total resistance can be as high as 100,000 ohms, while torque is less than 0.2 oz-in. Unit is built with either a linear or a functional output.

TESTING

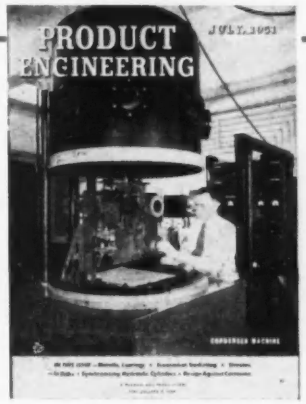
THE ANTI-ICING SYSTEM in the vertical stabilizer of the B-47 must be tested at 12 psi before the stabilizer is attached to the dorsal fin. The hot air passage is D-shaped--about 8 in. across the D's straight edge, with a circular duct 4 in. in diameter inside the D. Boeing engineers have designed a plug of inflatable rubber, shaped exactly like the opening. Inflated through a tire valve, its outer and inner edges seal the hole perfectly. Rubber tie bars are fastened inside to keep the plug from bulging anywhere except around the edges that do the sealing.

RECORDING OSCILLOGRAPH can be set to any one of ten writing speeds. Plots are made on transparent chart paper that can be projected and reproduced in any desired form. Frequency range is from zero to 600 cps; measuring range from five to 160 v or between two and 60 ma; and sensitivity about 0.1 mm per volt.

CONSIDERABLE RESEARCH is being conducted on luminous condensers, which are the basis of electroluminescent lighting. Sylvania has combined a special phosphor powder with a nonconducting plastic and spread it on a conducting glass. Metal foil is then applied over the mixture and the terminals of a 60-cycle power line connected to the foil and the glass. Each time the current reverses, the condenser discharges, resulting in a luminous glow. The higher the frequency the brighter the glow.

THE SURFACE ROUGHNESS of plane surfaces is simple to determine with a new pneumatically-operated gage. Measuring head is a small metal cylinder closed at one end. With the open end held against a given surface, compressed air within the cylinder leaks out between surface and cylinder in proportion to the roughness of the surface. Pressure variations are then amplified and indicated on a dial calibrated for a given range in average units for the area under the cylinder.

SIMPLE, LOW-COST METHOD for conducting structural model tests of welds in heavy steel plate has been developed at the Naval Research Laboratory. Method features the bulging of a welded plate with an air blast set up by the detonation of an explosive. Test has provided basic information for fracture problems.



THIS MONTH'S COVER

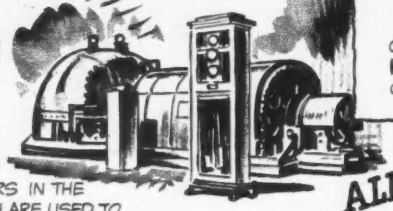
A vacuum vapor-plating machine at Bell Telephone Laboratories is used in making metallized paper capacitors. The plating occurs in the upper section normally covered with the evacuated bell jar. Below the work table are oil diffusion pumps, transformers, speed control and the water-cooling coils. The new capacitor contains lacquered paper with an electrode deposited on one side in the form of a thin metal film. A capacitor unit is made by winding two such sheets together so that the electrodes are separated by a single thickness of paper. The resulting units are, depending on the operating voltage, as small as 25 percent the size of their counterparts of conventional construction with the same impregnant. In the latest model telephone set designed by Bell Laboratories, the use of metallized paper construction has reduced the size of a "talking" capacitor unit about 65 percent.

Do You Know?

... BURGLAR ALARM SYSTEMS, WHICH PROTECT BANK DEPOSITS TOTALLING MILLIONS OF DOLLARS, RELY FOR THEIR UNFAILING PERFORMANCE ON **TELECHRON** TIMING MOTORS.

... SPUR GEARS OF ALL **TELECHRON** TIMING MOTORS ARE **HOBBED**... NOT STAMPED... FOR TRUER, QUIETER OPERATION AND LONGER LIFE.

... ACCURATE ELECTRIC TIMING, FOR THE MOST PART, RESULTS FROM THE **TELECHRON** SYNCHRONOUS MOTORS IN THE MASTER CLOCKS WHICH ARE USED TO CONTROL FREQUENCIES IN POWER STATIONS.



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Telechron®

ALL TELECHRON TIMING MOTORS ARE INSTANTLY... CONSTANTLY SYNCHRONOUS

no ONE chain serves every purpose

This Link-Belt universal crescent flat top chain travels around vertical curves, as well as the sharp horizontal bends shown here, in the Cranford, New Jersey plant of Johnson & Johnson. Jars of Baby Cream take this irregular path so that they cool properly before being capped, each always riding separately on its own chain top plate.

LINK-BELT offers the RIGHT chain for every job... engineered to meet your requirements

Typical conveyor chains from the complete Link-Belt line

S-815 flat top conveyor chain—economical, sturdy, reliable, easy to detach and to keep clean.

Class 400 swivel chain—carries cartons, cases, etc. over paths with both vertical and horizontal turns.

Class RC flat top chain—precision made for smoothest, spill-free carrying and long life.

Class RC crescent flat top chain—travels in horizontal planes, around corners; ideal for bottles and cans.

Link-Belt offers no single "cure-all" chain to handle every job. From the most complete line of chains and sprockets in the world—we can recommend the *exact* type to fit your particular job requirements—cast, combination, forged and fabricated steel, roller or silent for conveying and power transmission service. So, whatever your chain problems, big or small, Link-Belt engineers will work with you or your consultants to help solve them.

LINK-BELT COMPANY, Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Springs (South Africa). Offices, Factory Branch Stores and Distributors in principal cities. 12.208-E

LINK-BELT

CHAINS AND SPROCKETS

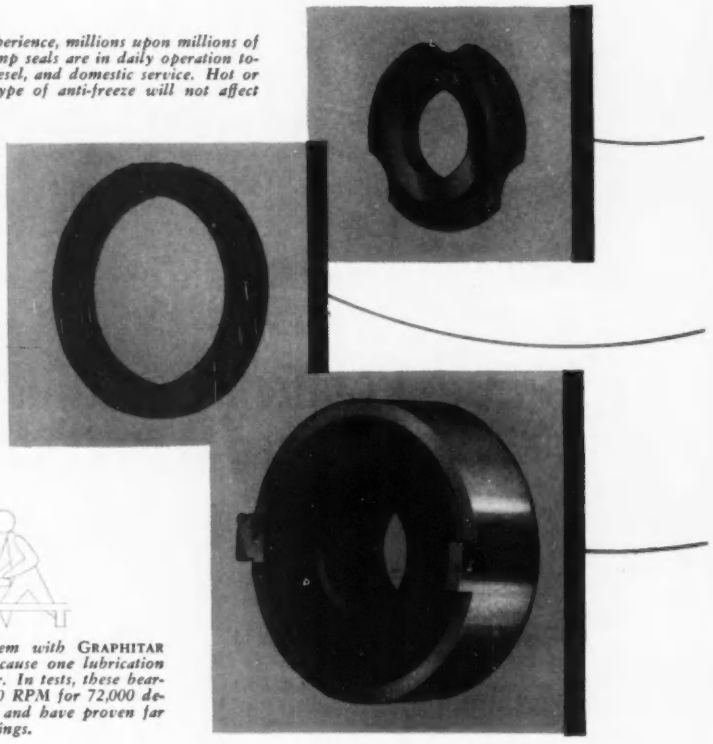
12,000,000 GRAPHITAR®
(CARBON-GRAPHITE)

HELP KEEP AMERICA'S AUTOMOBILES

It's a push-button automotive age! Today, over 30 million American car owners expect their automobiles to run smoothly any time—anywhere—without trouble. GRAPHITAR parts help make this dependability possible. GRAPHITAR'S unique characteristics make it ideal for such automotive applications as clutch release bearings, water pump seals, fluid coupling and torque converter seals and thrust washers. The controlled porosity of GRAPHITAR gives metered lubrication for hard-to-reach and hard-to-service installations. GRAPHITAR will not seize, score, or warp and has been proven by billions of miles on millions of cars that it will give durable service as a seal, bearing or thrust washer.

Backed by *19 years experience, millions upon millions of* GRAPHITAR *water pump seals are in daily operation today in automotive, diesel, and domestic service. Hot or cold water, or any type of anti-freeze will not affect* GRAPHITAR *seals.*

Over 2,000,000 GRAPHITAR *seals have been produced for use in automotive fluid couplings. Lapped on both faces to 35 millionths of an inch,* GRAPHITAR *seals retain hot oil under pressure, will not gall or leak, and afford maximum resistance to friction and wear.*

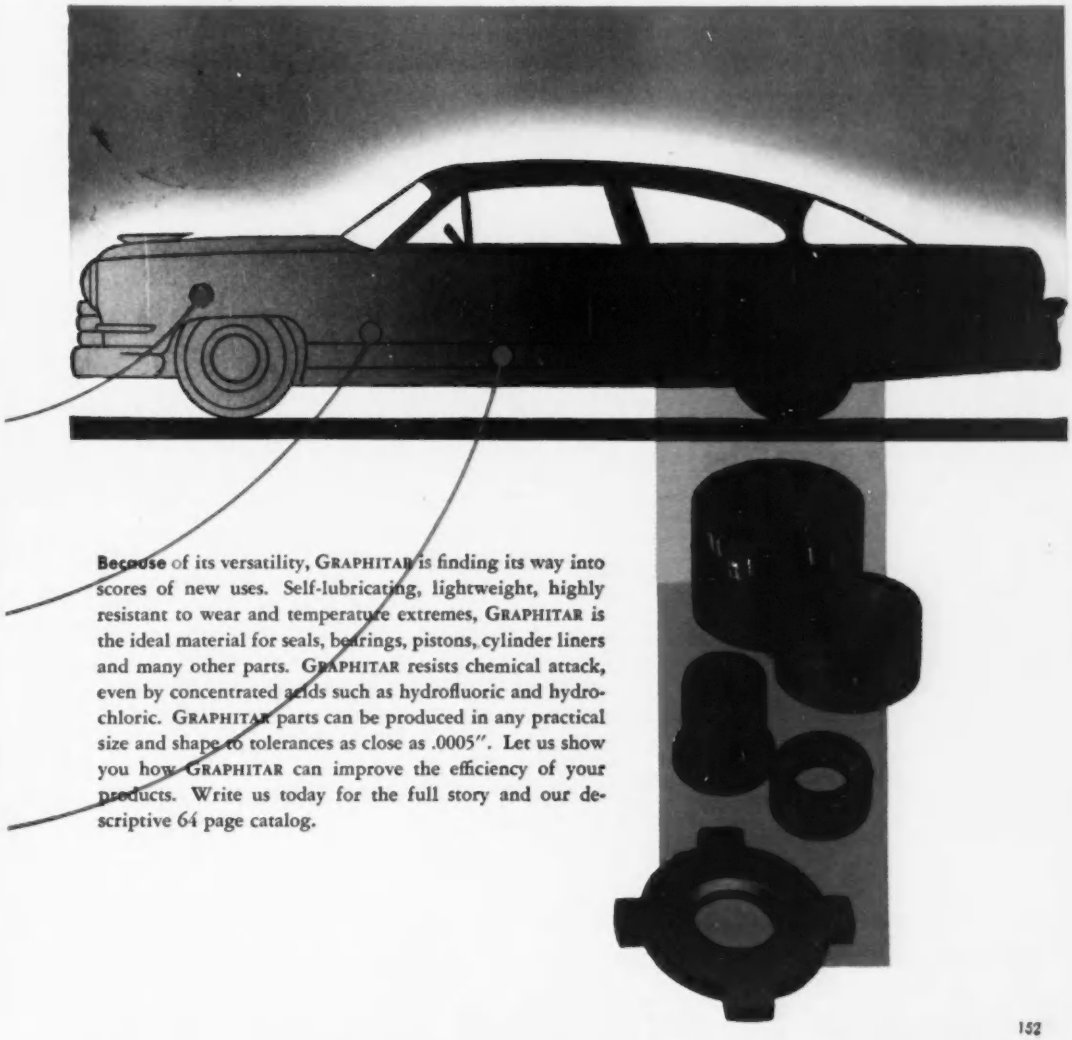


Maintenance isn't a problem with GRAPHITAR *clutch release bearings because one lubrication will last the life of the car. In tests, these bearings have operated at 3600 RPM for 72,000 declutchings without failure and have proven far superior to ordinary bearings.*

THE UNITED STATES

PARTS

RUNNING SMOOTHLY



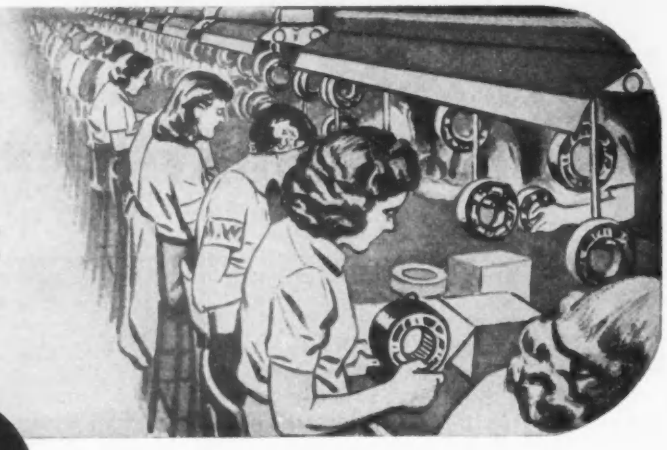
Because of its versatility, GRAPHITAR is finding its way into scores of new uses. Self-lubricating, lightweight, highly resistant to wear and temperature extremes, GRAPHITAR is the ideal material for seals, bearings, pistons, cylinder liners and many other parts. GRAPHITAR resists chemical attack, even by concentrated acids such as hydrofluoric and hydrochloric. GRAPHITAR parts can be produced in any practical size and shape to tolerances as close as .0005". Let us show you how GRAPHITAR can improve the efficiency of your products. Write us today for the full story and our descriptive 64 page catalog.

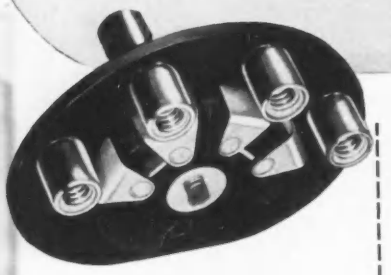
152

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW, MICHIGAN

Service Beyond The Sale!





Mallory Voltage Change Switch Adds Versatility To Electric Motors

THE MALLORY MOTOR VOLTAGE CHANGE SWITCH

Stator contacts are phosphor bronze, silver-plated... insuring constant contact tension and maximum electrical conductivity. Rotor contact slugs are brass, silver-plated. High grade phenolic stator and rotor insure maximum mechanical strength. Standard shaft is milled to fit 5/32" open ended wrench. Shaft end may be machined to specifications. Requires only one setting at time of original installation of the motor.

The Mallory motor voltage change switch is a simple, effective device which makes possible the universal application of electric motors.

The switch connects two field windings in parallel for 110 volt operation, and in series for 220 volt operation. It is ruggedly constructed, is capable of withstanding motor vibration and is equipped with junction terminals. It permits standardization on a single line of motors, reducing both production and inventory problems and eliminates a field replacement headache by fitting one standard motor to the requirements of two different applications.

That's service beyond the sale!

Mallory's electrical know-how is at your disposal. What Mallory has done for others can be done for you.

Television Tuners, Special Switches, Controls and Resistors

P. R. MALLORY & CO. Inc.

MALLORY

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

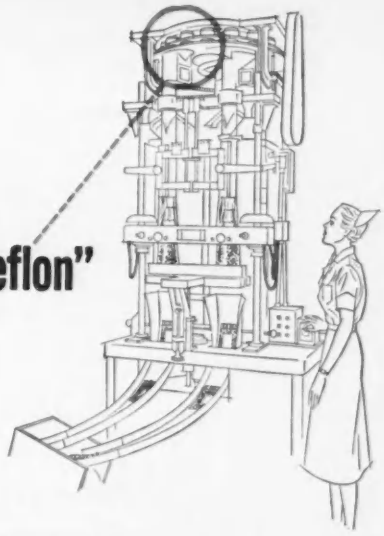
SERVING INDUSTRY WITH

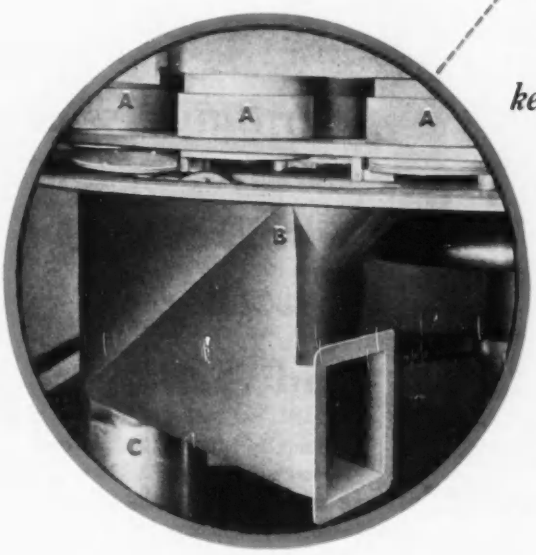
Electromechanical Products
Resistors *Switches*
TV Tuners *Vibrators*

Electrochemical Products
Capacitors *Rectifiers*
Mercury Dry Batteries

Metallurgical Products
Contacts *Special Metals*
Welding Materials

Non-adhesive liners of Du Pont "Teflon"





HERE YOU SEE parts of the automatic packaging machine lined with non-adhesive "Teflon." Feeding pockets (A) have trap doors which swing open, dumping product into feeding hopper (B) and, in turn, into packaging tube (C). Pockets, hopper, and tube are lined with "Teflon".

keep sticky foods moving smoothly through packaging process

This machine makes packages at the rate of 50 to 120 per minute, fills them with the manufacturer's product, and seals them. As the food (frozen foods, candy, salted nuts, etc.) is dumped from feeding pockets to hoppers and then down a tube for packaging, it is constantly in contact with the surface of the equipment. Thus, without a non-adhesive lining, particles of food could stick to the equipment, cause improper packaging and costly work stoppage while the machinery is cleaned.

To solve this problem, linings of Du Pont "Teflon"* tetrafluoroethylene resin were installed in Stokes & Smith's "Stokeswrap" machine. Since *nothing* will stick to "Teflon" with any appreciable strength, even the stickiest foods move smoothly through the process without adhering to equipment. Waste and work stoppage are prevented. In addition, dies which make both the end seam and longitudinal seams of the package are lined with "Teflon" to prevent package from sticking to sealing faces.

Industry uses "Teflon" in many operations involving handling of sticky materials. And it has many other uses. "Teflon" is an extremely tough and durable, yet flexible, plastic. It is the most highly heat-resistant and chemically inert of all commercial thermoplastics.

Du Pont "Teflon" may help you, as it has so many companies, to improve a product or process. Demand for "Teflon" currently exceeds supply. However, we suggest you investigate its versatile properties for future application. We will gladly discuss the availability of experimental quantities. For additional information on "Teflon" and other Du Pont plastics, write:

*REG. U. S. PAT. OFF.

E. I. du Pont de Nemours & Company (Inc.)
Polychemicals Department, District Offices:
350 Fifth Avenue, New York 1, New York
7 S. Dearborn St., Chicago 3, Illinois
845 E. 60 St., Los Angeles 1, California

DU PONT
REG. U. S. PAT. OFF.
PLASTICS
Better Things for Better Living
. . . through Chemistry

"Stokeswrap" automatic packaging machine made by Stokes & Smith Co., Philadelphia

COST COMPARATOR

Springtites and Sems vs. Old Methods of Fastening

(From pages 4 and 5 of Eaton Springtites and Sems Engineering Bulletin S-49)

To figure savings you can make with Eaton Springtites or Sems:

(1) Determine average number of washers and bolts your worker can assemble in one hour.
(2) Find assembly cost per thousand at hourly labor rate paid in chart below.
(3) Add overhead based on direct labor to get total labor cost of hand assembly.
(4) Add cost of unassembled bolts and washers.
(5) Deduct cost of Eaton Springtites and Sems.

ASSEMBLY COST PER THOUSAND

Pieces Assembled per hour	HOURLY LABOR RATE $0.75	$1.00	$1.25	$1.50	$1.75	$2.00
500	$1.50	$2.00	$2.50	$3.00	$3.50	$4.00
550	1.36	1.82	2.27	2.73	3.18	3.64
600	1.25	1.67	2.08	2.50	2.92	3.33
650	1.15	1.54	1.92	2.31	2.69	3.08
700	1.07	1.43	1.79	2.14	2.50	2.86
750	1.00	1.33	1.67	2.00	2.33	2.67
800	.94	1.25	1.56	1.88	2.19	2.50
850	.88	1.18	1.47	1.77	2.06	2.35
900	.83	1.11	1.39	1.67	1.94	2.22
950	.79	1.05	1.32	1.58	1.84	2.11
1000	.75	1.00	1.25	1.50	1.75	2.00

Cost of Labor (from chart above) $_____
Overhead on Direct Labor _____
Total Labor Cost $_____
Cost of Unassembled Screws or Bolts _____
Cost of Unassembled Washers _____
Total Parts Cost $_____
Total Parts and Labor Cost $_____
Cost of Eaton-Springtites or Sems (deduct) $_____
SAVING

* *Springtites*
Quality Reliance Spring Lock Washers of proper size and weight pre-assembled on bolts or screws ready for the assembly.

† *Sems*
Same as Springtites but with multi-prong washers of any type instead of spring lock washers.

YOU

can figure your own savings with EATON *Springtites** and *Sems*†

- Eaton Springtites and Sems cut assembly motions from 8 to 3.
- The saving is obvious — and especially important at today's high labor rates.
- You can get some idea of what it amounts to from the chart at the left.
- If you'd like to know what it would mean to you in dollars and cents, write your nearest Eaton-Reliance office for prices on your requirements.

EATON

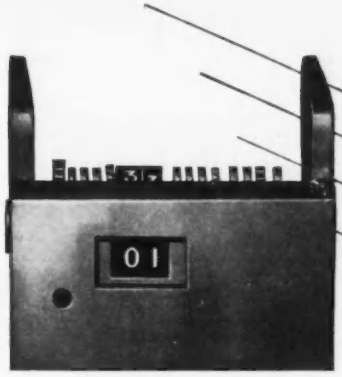
EATON MANUFACTURING COMPANY

Springtites and SEMS

PRE-ASSEMBLED WITH ALL TYPES OF SCREWS AND WASHERS

RELIANCE DIVISION, MASSILLON, OHIO

Sales Offices: New York, Cleveland, Detroit, Chicago, St. Louis, San Francisco, Montreal
In Canada: Eaton Automotive Products, Ltd., London, Ontario

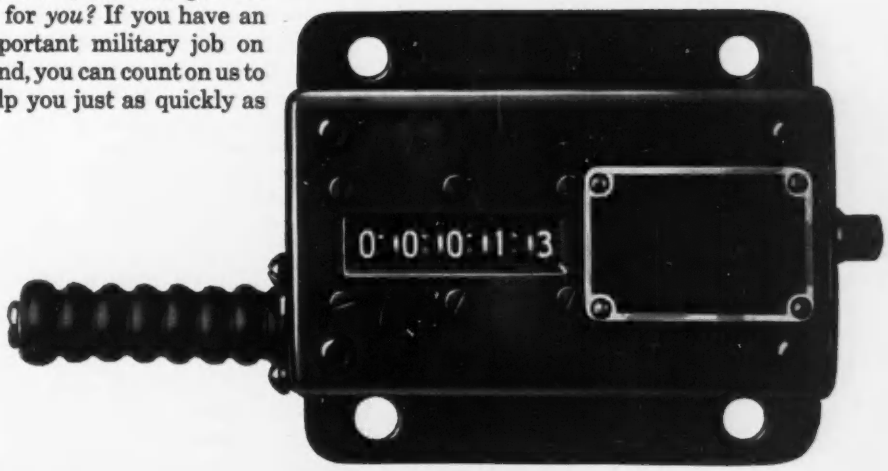


A lot of "Military Intelligence" comes from counters like these... because every branch of the service... in fact...

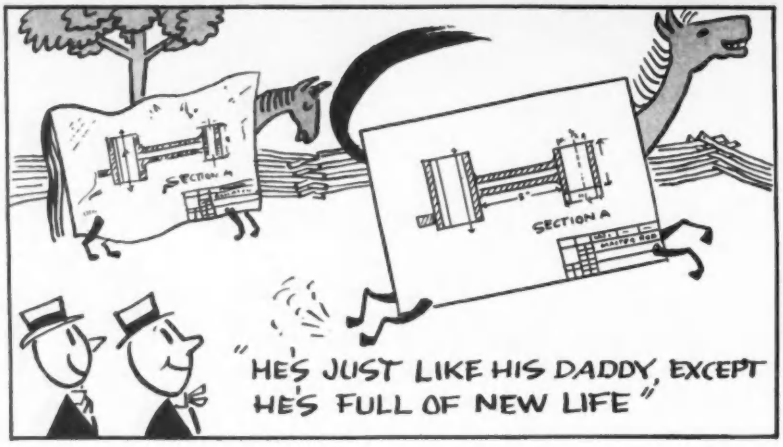
Everyone Can Count on VEEDER-ROOT

Shown here are an aircraft and an artillery counter. What they do, and how they do it, is "nobody's business" but that of the military personnel using them. And now, what might we do for *you?* If you have an important military job on hand, you can count on us to help you just as quickly as our present military commissions will permit.

VEEDER-ROOT INCORPORATED
"The Name That Counts"
HARTFORD 2, CONN. • GREENVILLE, S. C.
Montreal, Canada • Dundee, Scotland
Offices and agents in principal cities

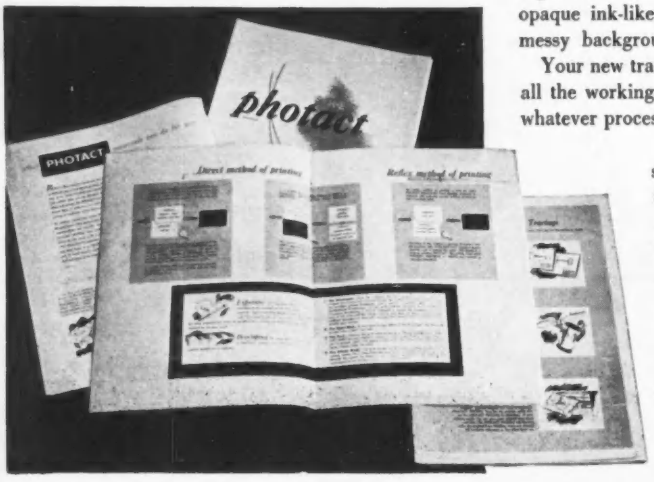


VEEDER-ROOT COUNTERS *"Count Everything on Earth"*



PHOTACT* makes 'em young again

A fresh start—that's what you get with K&E PHOTACT* materials. Even if your original tracing is old, soiled, tattered and torn—too far gone to make half-way readable reproductions—you can have a new tracing without having to draw it all over again.



From your battered original you can have a PHOTACT "second original," more vigorous, keener than its daddy ever was, even the day he was born.

You never saw a job of rejuvenation like a PHOTACT "second original" on tracing paper or tracing cloth. Weak, blurred lines are turned into solid, opaque ink-like black lines. Fingermarked, smeared, messy backgrounds become clean, clear and white.

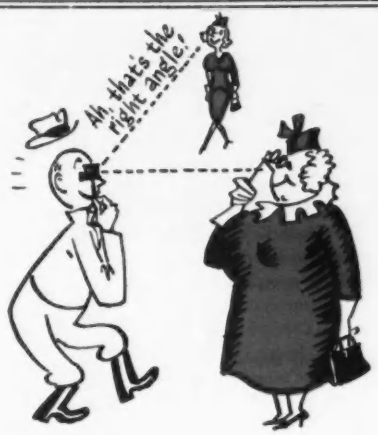
Your new tracing is young and peppy, and good for all the working prints you want to make from it, by whatever process you prefer!

PHOTACT "second originals" can serve you other ways, too. For instance, they save the time and expense of ink tracings, when you have to furnish them to the government or to contractors. PHOTACT "second originals" are accepted . . . they are every bit as good.

K&E offers a booklet on PHOTACT materials that may give you some useful ideas. It explains the simple process. Ask your nearest K&E Distributor or Branch, or write to the main office at Hoboken.

*Trade Mark

It's hard to get a right angle, these days.

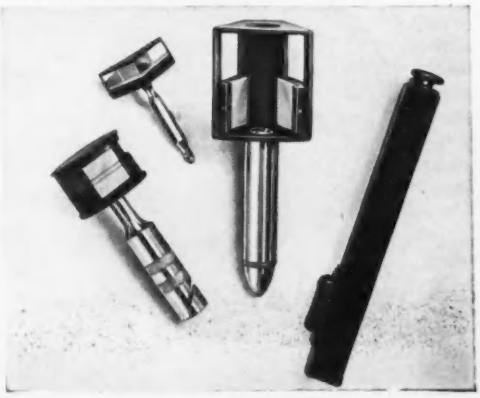


In today's cockeyed world it takes more than a pocket-size gadget to give you the right angle on things. Or does it?

No, by Euclid, that's exactly what a K&E Right Angle Prism or a K&E Right Angle Mirror will do. And it will fit in your pocket, besides.

These versatile little fellers will do plenty for you. They'll measure plusses of things that aren't on the survey line. They'll measure offsets and save you "swinging" tape. They'll take cross sections, help you stake out small structures, lay out squares for contouring and do a whole lot of surveying jobs as well. They'll even give you a hand in laying out circular curves.

They are a family of four. You can take your choice and you may want to ask your nearest K&E Distributor or Branch for the K&E Booklet "Right Angles with Pocket Instruments". Or just write to Keuffel & Esser Co., Hoboken, N. J.



There's a laugh in many a graph

Graphs have been kidded, but the fact remains that graphs know their business, and that business knows its graphs.

Keuffel & Esser make over 300 kinds of graph sheets and co-ordinate papers and cloths. They are for three main purposes:

1. for plotting engineering or scientific "dissa and data"—square or rectangular section, logarithmic, reciprocal, electrical and so forth.
2. as guides for sketching or drawing—mechanical, architectural, surveying or mapping.
3. for plotting business or statistical data—time series, percentages, etc.

They come in continuous rolls, in sheets and in pads, in various grades of paper (including famous ALBANENE*), and cloth. Somebody could write a book on *K&E Graph Sheets*, and somebody has. Get a copy! It describes K&E's 300 types.

*Trade Mark ®

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For 83 years K&E equipment and materials have been partners of the draftsman, engineer and scientist in shaping the modern world.

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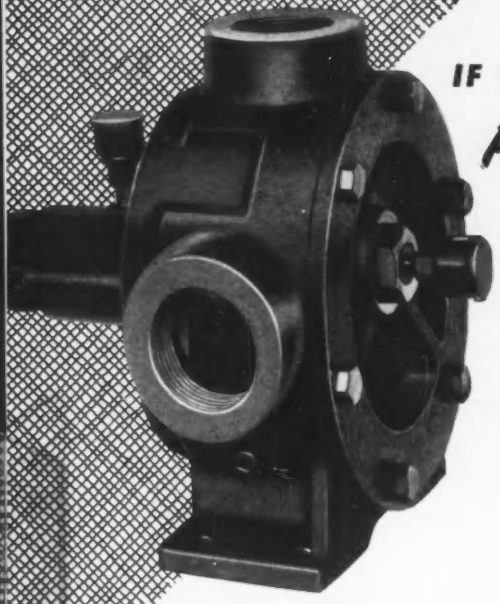
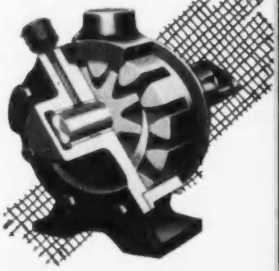


IF YOU'RE LOOKING FOR

Positive Pumping Performance

. . . then look over the Fairbanks-Morse Rotary Pump line. These positive-displacement pumps assure a steady flow of any free-flowing liquid . . . minimize vibration and shock . . . assure long, low-cost service.

Only *two* parts move . . . a precision-cut rotor and pinion gear. There are no complicated parts to cause trouble or require frequent adjustment or maintenance. Capacities range from 1.3 to 450 g.p.m. . . . sizes from ⅜ to 5 inches. You'll find a Fairbanks-Morse Rotary Pump the ideal answer to any design problem involving positive pumping of free-flowing liquids.



This cross-section clearly illustrates the only two moving parts that impart the positive pumping action of Fairbanks-Morse Rotary Pumps.

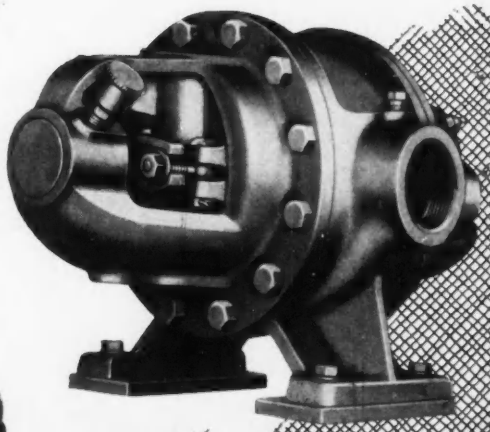
FAIRBANKS

A NAME WORTH

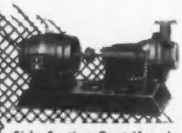
OR, MULTI-STAGE BENEFITS FROM A

Single Stage Pump

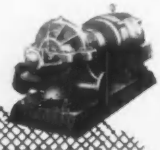
. . . then look over Fairbanks-Morse Westco Turbine type pumps. A Westco is the one pump that gives you multi-stage benefits from a single stage pump . . . that reduces operating and maintenance costs through balanced impellers and replaceable liners . . . that handles widely varying heads with little loss of capacity with *no* change in operating speed . . . that minimizes vapor locking. If you need these advantages in your designs, then you need Westco. Sizes from 1 to 200 g.p.m.



Other Fairbanks-Morse Pumps include:



Side-Suction Centrifugals



Split-Case Centrifugals

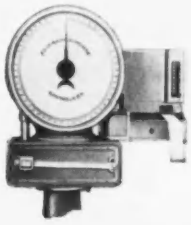
Builtogether Centrifugals

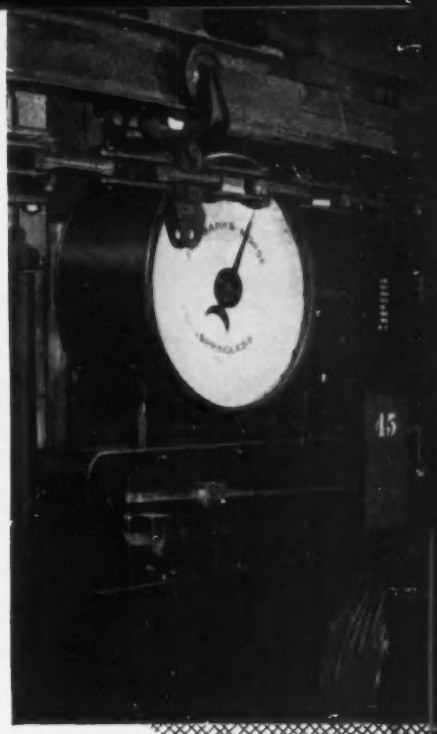
IF IT'S A

Matter of Record....

If the matter of automatic recording of weights . . . if accurate automatic control of batching, processing, materials handling or production machinery are required essentials of your designs, check the possibilities of Fairbanks-Morse Printomatic Weighers.

These lastingly accurate weighing instruments record weights automatically . . . assure accurate permanent records. They can, through the use of electronics, accurately control machines or proportioning equipment. They can be fitted in as an essential part of a production or materials handling line . . . control material flows. For any operation involving automatic weighing or materials control, it will pay you to check Printomatic.



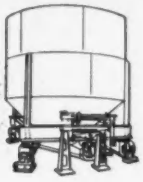


MORSE REMEMBERING

IF IT'S A

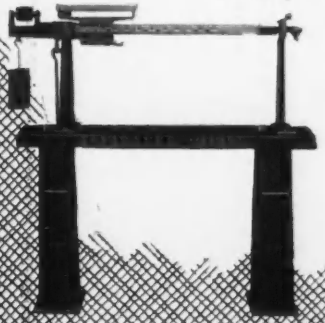
Matter of Weight

the complete line of Fairbanks-Morse Scales provides an economical answer to any weighing problem. Beam and dial scales in a wide variety of types and capacities . . . truck scales . . . hopper scales . . . railroad track scales . . . and special service scales . . . fit any weighing requirement. Fairbanks-Morse Scales or *component scale parts* can be supplied to fit right into your equipment for weight or control operations. A Fairbanks-Morse weighing expert will be happy to work with you on any scale problem.

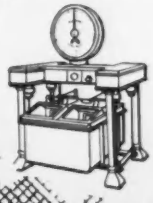


Hopper Scale

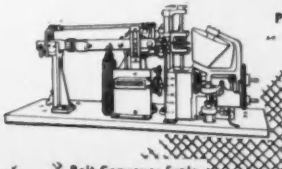
Portable Dial Scale



Full Capacity Beam Scale



Weigh Can Scale



Belt Conveyor Scale

..YOU WANT THIS ROTOR DESIGN...

It's Copperspun!

If you buy or use motors, chances are that most of them are of the polyphase squirrel cage type — the most widely used class of integral horsepower motors made — for sustained heavy-duty drives in almost every class of service.

In rotor design, such service separates the good from the poor — and highlights your need for Fairbanks-Morse motors with Copperspun rotors, made through an exclusive centrifugal casting procedure developed by Fairbanks-Morse.

For in Copperspun rotors, you get the benefits of superior electrical characteristics — plus a design that is mechanically stronger for withstanding the most severe working conditions.

FAIRBANKS

A NAME WORTH

FOR POLYPHASE SQUIRREL-CAGE MOTORS

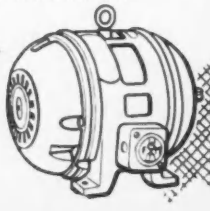
with Copperspun Rotors!

Here are a few in the complete Fairbanks-Morse line

GENERAL PURPOSE, drip-proof motors mountable in any position with full protection against flying chips, falling particles, dripping liquids, etc.

AXIAL AIR-GAP MOTORS: Averaging 30% lighter and 40% shorter overall—with flywheel effect three times that of corresponding ratings of conventional motors. Add to appearance, decrease size and weight of any driven machine. Meet all AIEE and NEMA standards.

TOTALLY ENCLOSED FAN-COOLED motors operate economically, safely under adverse conditions, including corrosive gas, vapors, steam or where metallic particles, abrasive dust and/or other materials are in the air. Available with Underwriters labels for use in Class 2, Group G hazardous locations.



FOR THESE EXCLUSIVE ADVANTAGES

Compare!

The Fairbanks-Morse Copperspun rotor design shows up at its best under comparison. It contrasts the mechanical strength and superior electrical characteristics of copper—against the poorer showing of aluminum and other white metal alloys. It contrasts new standards for uniformity and strength made possible through its precisely controlled centrifugal casting—against the results obtainable through standard, even old-fashioned, manufacturing procedures.

Finally, comparison drives home the virtues of indestructibility, homogeneity and high electrical efficiency. That means more satisfactory operation of motors with the Fairbanks-Morse Copperspun rotor.

ONLY COPPERSPUN ROTOR OFFERS THESE ADVANTAGES:

- ★ A truly one-piece indestructible copper rotor winding.
- ★ Withstands higher temperatures: (melting point 2,000° F. for Copper, 1,100° F. for Aluminum)
- ★ High electrical and thermal conductivity.
- ★ Dense, uniform grain structure.
- ★ Separately mounted fans: permitting complete overall machining, better quality control, better dynamic balance.

FAIRBANKS-MORSE

REMEMBERING

THESE ARE YOUR FAIRBANKS-MORSE SALES CENTERS

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760 Lee St., S. W.
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BElmont 5258

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626 N. Ninth St. Zone 4
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178 Atlantic Avenue
LAfayette 3-3600

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33 Franklin St.
Lincoln 4210

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11110 East Warren Ave.
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INDIANAPOLIS 2, IND.
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FRanklin 3684
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JEfferson 8151

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CAlhoun 1469

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RAymond 3115

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80 Broad St.
HAnover 2-7470

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ATlantic 3122

PHILADELPHIA 8, PA.
401 N. Broad St.
WA 2-4100

PITTSBURGH 24, PA.
4301 Main Street
SHenley 1-3123

PORTLAND 14, OREGON
105 S. E. Taylor St.
EAst 0131

PROVIDENCE 3, R. I.
187 Pine Street
GAspee 1-1531

ST. LOUIS 2, MO.
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CHestnut 7483

ST. PAUL 1, MINN.
220-26 E. Fifth Street
GArfield 4335

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3-2108 & 3-5139

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TULSA 3, OKLA.
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3-8231

WASHINGTON 5, D. C.
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District 6694

FAIRBANKS-MORSE de MEXICO S. A.
Balderas 146, Mexico 1, D. F. Mexico
10 06 74 y 10 09 58

Export Division:
NEW YORK 4, N. Y.
80 Broad Street—HAnover 2-7470

when the call comes for a change in shape, size or material . . . machines equipped with

REEVES

Variable Speed Drives make the "changeover" easier! faster! cheaper!

In many plants only partially converted to defense production, the machines you build are being called upon to turn out military supplies part of the time and civilian products the rest of the time. Today they may be producing a part made of steel, but tomorrow the schedule may call for an aluminum part of different shape and size.

These conditions place a premium on machines with top "changeover capacity" . . . machines that can be shifted quickly and economically from job to job—from one shape, size or material to another.

That's what REEVES Variable Speed Drives can do for the machines you build. Give them *extra* "changeover capacity" by providing the right speed—with the turn of a handwheel, touch of a button, or automatically, without stopping the machine—for each different product or material.

REEVES stepless speed adjustability pays another important bonus, too—because it permits machine speed to be adjusted to match the skill of the individual operator. Beginners can work slowly while learning—a protection for costly machinery. Skilled operators can work at high speed. But, *always*, uniform quality is maintained.

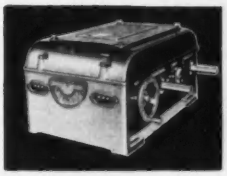
REEVES Variable Speed Drives—now standard equipment on 2,615 leading makes of machines—can be incorporated easily in your new designs because REEVES is the only complete line of variable speed drives in existence. Built around the three basic units shown opposite, it offers a wide selection of horsepower capacities, speed ratios and designs—with manual, electric, and completely automatic hydraulic or mechanical controls.

An experienced REEVES Speed Control Engineer will be glad to give you complete details in relation to your own particular requirements. Write for his name—no obligation, of course.

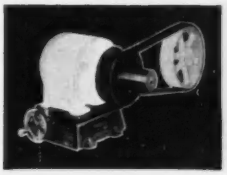
REEVES PULLEY COMPANY • COLUMBUS, INDIANA

Recognized leader in the specialized field of speed control engineering

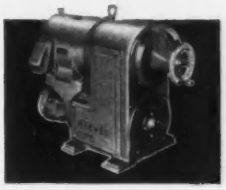
for the machines you build, your choice of these three basic REEVES units



VARIABLE SPEED TRANSMISSION provides infinite, accurate, stepless speed adjustability over a wide range—as high as 16 to 1. Sizes to 87 hp.

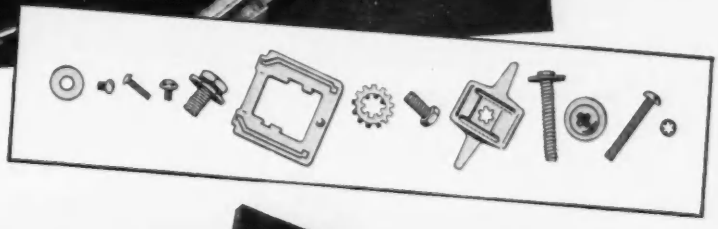


VARI-SPEED MOTOR PULLEY converts any standard, constant-speed motor to variable speed drive. Speed variations to 4 to 1. Sizes to 10 hp.



VARI-SPEED MOTODRIVE combines motor, speed-changing mechanism and gear reducer in one unit. Speed variations as great as 10 to 1. Sizes to 20 hp.

A REEVES Vari-Speed Motor Pulley drives the conveyor to provide accurate time control for each of these six continuous draw furnaces installed in the Elgin (Ill.) plant of Shakeproof Inc.—a Division of Illinois Tool Works. Manufactured by Sunbeam Stewart Industrial Furnace Div., Sunbeam Corp., Chicago, the REEVES-equipped units provide close control in order to assure proper heat treatment, at highest production rate, for each of the many metal fastenings processed, some of which are shown in the inset photo, below.

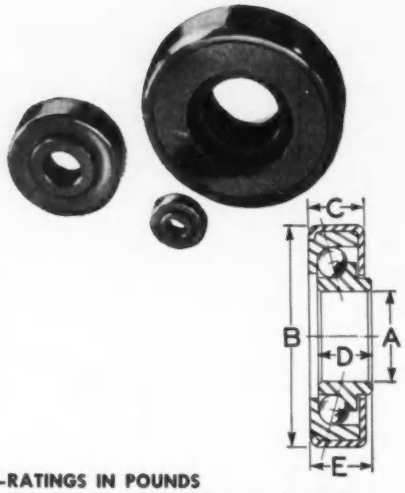


accurate · variable **REEVES** *Speed Control*

Ask for complete information, including engineering drawings and technical data, on the full line of REEVES Variable Speed Drives and Controls. Send for catalog No. K73-3N.

"Commercial" Ball-Bearing Data...

TYPE A UNGROUND
RADIAL-THRUST BALL BEARINGS



APPLICATIONS: For anti-friction performance equal to expensive precision bearings where load and speed requirements are within limits of "Commercial" ball-bearing ratings (see table below).

Replace plain sleeve bearings or bushings—often at no greater cost, since costly machining and assembly time is eliminated.

For combination radial and thrust loads or pure radial loads—almost limitless applications.

FEATURES:

Ball-bearing performance at low cost.
Race rings are carefully machined and smoothly finished—carburized, hardened and tempered.
Case—pressed on outer ring—is drawn from unhardened flat steel.
Balls are of highly polished, hardened steel.

DIMENSIONS IN INCHES—RATINGS IN POUNDS

Bearing No. New	Bore A +.004" −.000"	Outside Diam. B +.002" −.002"	Width C	Width D	Width E +.010" −.010"	Balls		Load Rating at 600 RPM
						No.	Size	
CS 1777X1	1/8	11/16	1/16	3/32	9/32	11	1/8	29
CS 1778X1	.192	11/16	1/16	3/32	9/32	11	1/8	29
CS 1779X1	3/16	11/16	1/16	3/32	11/64	11	1/8	29
CS 1780X1	1/4	13/16	25/64	21/64	25/64	10	5/16	60
CS 1781X1	1/4	3/4	1/4	13/64	13/64	12	1/4	31
CS 1782X1	5/16	13/64	13/32	11/32	7/16	11	5/16	65
CS 1783X1	3/8	15/64	1/2	3/8	17/32	11	1/4	115
CS 1784X1	3/8	17/32	1/2	3/8	9/16	13	1/4	135
CS 1785X2	.445	29/32	19/64	17/32	5/8	16	1/8	42
CS 1786X1	1/2	17/32	1/2	3/8	9/16	13	1/4	135
CS 1787X1	9/16	11/32	1/2	7/16	9/16	13	1/4	135
CS 1788X1	9/16	15/64	17/32	7/16	11/16	13	5/16	210
CS 1810X1	9/16	25/64	25/64	3/8	11/16	13	5/16	410
CS 1789X1	5/8	23/64	17/32	9/16	41/64	14	5/16	230
CS 1790X1	5/8	25/16	5/8	17/32	11/16	17	5/16	260
CS 1791X1	1	25/16	5/8	17/32	11/16	17	5/16	260
CS 1792X1	1	2 5/8	25/64	5/8	11/16	13	7/16	410
CS 1793X1	1 1/8	2 5/16	5/8	17/32	11/16	17	5/16	260
*CS 1794X1	1 1/4	3 3/16	27/64	23/32	25/32	14	1/2	580
*CS 1795X1	1 1/4	3 3/4	27/64	27/32	25/32	14	1/2	580
*CS 1796X1	1 1/2	3 3/4	27/64	25/32	25/32	14	1/2	580
*CS 1811X1	1 1/2	3 25/64	25/64	7/8	1 1/32	18	1/2	750
*CS 1797X1	1 1/2	3 25/64	25/64	7/8	1 1/32	18	1/2	750
*CS 1798X1	1 15/16	3 25/64	25/64	7/8	1 1/32	18	1/2	750
*CS 1799X1	2	4 1/2	1 1/32	1 3/64	1 5/32	18	5/8	940
*CS 1800X1	2 1/16	4 1/2	1 1/32	1 3/64	1 5/32	18	5/8	940

* Bearings so marked have bores ground to plus .001"-minus .000".

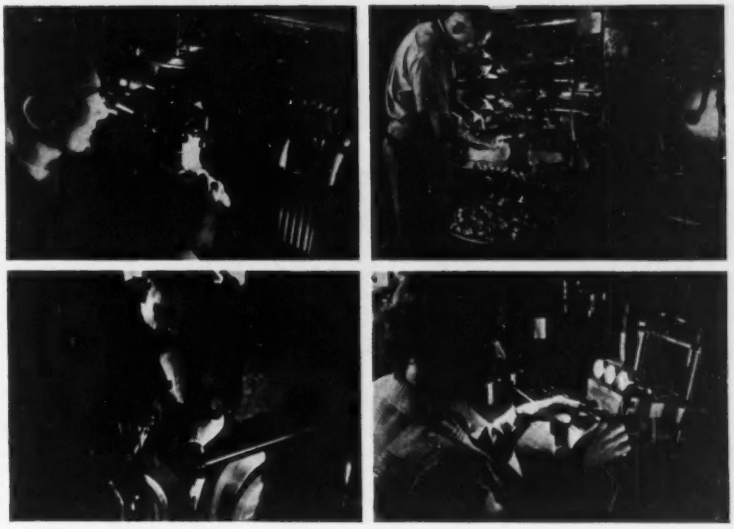
For load ratings at other speeds multiply the rating at 600 RPM by the following factors:

50 RPM	100 RPM	300 RPM	800 RPM	1000 RPM
2.50	1.80	1.30	.88	.78

SCHATZ
"Commercial"
BALL BEARINGS

If You Have a Friction Problem
Let Schatz Engineers Design it Away

THE SCHATZ MANUFACTURING COMPANY
6758 Fairview Avenue · Poughkeepsie, New York



Beating Friction...

with Mass Production of Quality Bearings

Federal—in making ball bearings—recognizes no shortcuts in the mass production of a quality product. Federal combines the skills of experienced workers with the capabilities of modern precision machinery. For thirty-five years, Federal has contributed to automotive engineering progress: fine ball bearings have helped engineers increase horsepower five-fold, double the useful life of the average car, in a short span of years.

Tractors, machine tools, textile machinery, construction equipment also demand quality in component parts like bearings. Sound manufacturing practices based on years of experience cause such manufacturers to rely on Federal as a ball-bearing supplier.

Federal's enviable backlog of manufacturing knowledge can help you overcome friction in your quality products. One reason Federal ball bearings can meet rigid performance standards is that Federal's comprehensive quality-control program literally checks and double-checks ball bearing production hour by hour. Check and double-check is a *must* at Federal for each ball bearing *before* it leaves the plant.

If you want top ball bearing performance in a product where tolerances are tight, look to Federal. Every Federal ball bearing is a product of the combined skills of IMAGINATIVE RESEARCH · ADVANCED ENGINEERING · ALERT MANUFACTURING · RIGID QUALITY CONTROL · SUPER-PRECISE TESTING.

THE FEDERAL BEARINGS CO., INC. · POUGHKEEPSIE, NEW YORK

Makers of Fine Ball Bearings

Quality Since 1908

Federal BALL BEARINGS

ONE OF AMERICA'S LEADING BALL BEARING MANUFACTURERS

DIE CASTING washes out the production "blues"

Montgomery Ward's modern washing machine with gyroscopic drive—a gearless mechanism designed for trouble-free service. (Built for Montgomery Ward by Apex Electrical Mfg. Co., Cleveland, Ohio)

CASE HISTORIES FROM MT. VERNON FILES

Die Casting eliminates those gloomy high cost factors that often threaten to "soak" you plenty once your projects begin to take shape on the drawing board.

For instance, it was the ***reduced cost of production,*** without sacrifice of quality, that determined the makers of Montgomery Ward's "Supreme" Automatic Washing Machine to specify die casting.

The aluminum basket hub (A) was originally sand cast. Die casting has reduced the initial cost of the casting, and cut machining costs.

The main bearing carrier (B) was originally a steel tube and flange, arc welded. Redesigned for die casting, this part is produced at a saving of approximately $2.50.

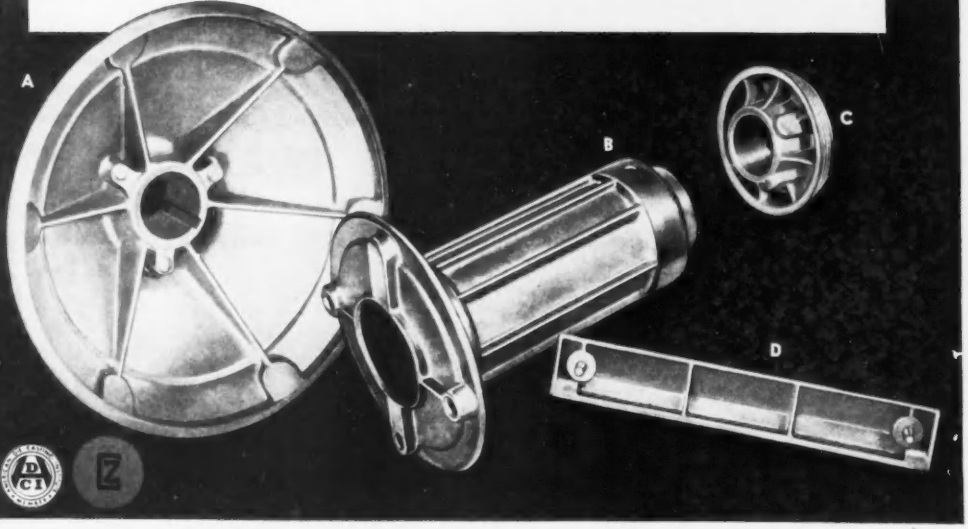
The cam collar (C) was originally turned from steel bar stock. Die cast, the item costs approximately 60¢ less to produce.

The portion of the lid hinge (D) was originally cast brass. As an aluminum die casting, about 25¢ have been pared from its production cost.

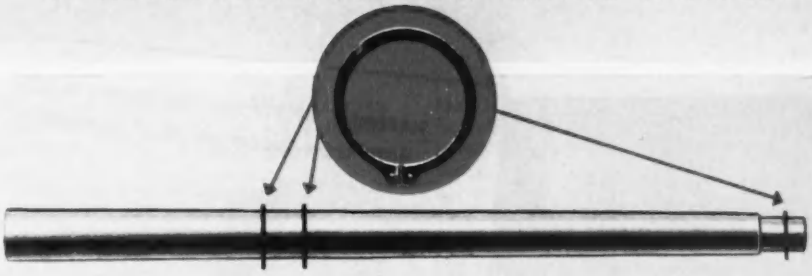
While it may be noted that prior to the adoption of die casting this washing machine was not in high volume production—and, consequently, initial unit costs probably did not represent the minimums attainable—yet it is certain that only die casting could effect the large savings realized.

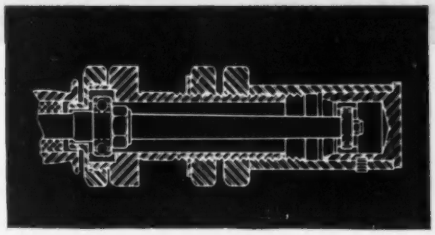
Before **you** schedule a manufacturing procedure, profit by ***consulting with us.*** We've helped many a producer to wash out high costs from his production picture . . . and obtain better products to boot! We'll gladly put our experience and facilities to work for you.

MT. VERNON
DIE CASTING CORP.
MT VERNON, NEW YORK

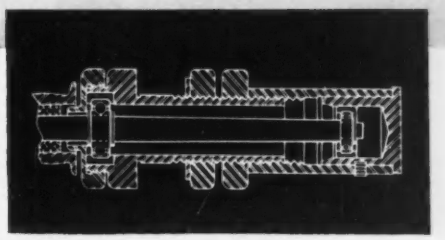


3 TRUARC RETAINING RINGS LOWER COST... IMPROVE PERFORMANCE OF REVOLUTIONARY NEW TEXTILE SPINDLE!





OLD CONSTRUCTION. To position 2 ball bearings, an oversize diameter rod had to be turned on a lathe to provide 3 shoulders. In addition, blade required 2 threading operations . . . 2 lock nuts . . . separate tapering operation. Proper pressure of nuts against ball bearings required skilled labor adjustment.



NEW CONSTRUCTION. Standard rod, equal in diameter to finished blade is used. Three grooves for Truarc Rings and shoulder are made quickly and easily on screw machine. Blade is economically tapered by centerless grinding. Truarc Rings maintain correct pressure on ball bearings for life of unit!

The H & B American Machine Company's new anti-friction CENTURY spindle is probably the most mechanically advanced spindle on the market today. Waldes Truarc Retaining Rings have eliminated many of the material, tooling and assembly costs...have kept its price competitive. Truarc Rings not only simplify spindle assembly, they position ball bearings accurately...simplify maintenance...eliminate skilled labor...improve performance! And there are Truarc Rings to solve any design or re-design problem!

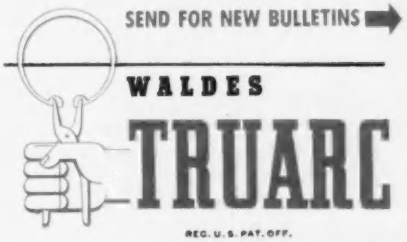
Redesign with Truarc Rings and you too will cut costs.

Wherever you use machined shoulders, bolts, snap rings, cotter pins, there's a Waldes Truarc Retaining Ring designed to do a better job of holding parts together.

Truarc Rings are precision-engineered...quick and easy to assemble and disassemble. Always circular to give a never-failing grip. They can be used over and over again.

Find out what Truarc Rings can do for you. Send your blueprints to Waldes Truarc engineers for individual attention, without obligation.

Waldes Truarc Retaining Rings are available for immediate delivery from stock, from leading ball bearing distributors throughout the country.



SEND FOR NEW BULLETINS

WALDES

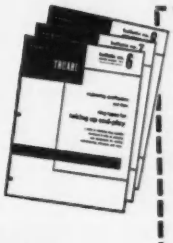
TRUARC

REG. U. S. PAT. OFF.

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS ARE PROTECTED BY THE FOLLOWING PATENT NUMBERS: 2,383,947; 2,398,949; 2,416,852; 2,420,021; 2,428,341; 2,467,602; 2,467,603; 2,491,306; 2,491,310; 2,509,081; AND OTHER PATS. PEND.



Waldes Kohinoor, Inc., 47-16 Austel Place PN073
Long Island City 1, N. Y.

Please send Bulletins 6, 7 and 8—giving engineering specifications for all types of Waldes Truarc Rings.

Name_____

Title_____

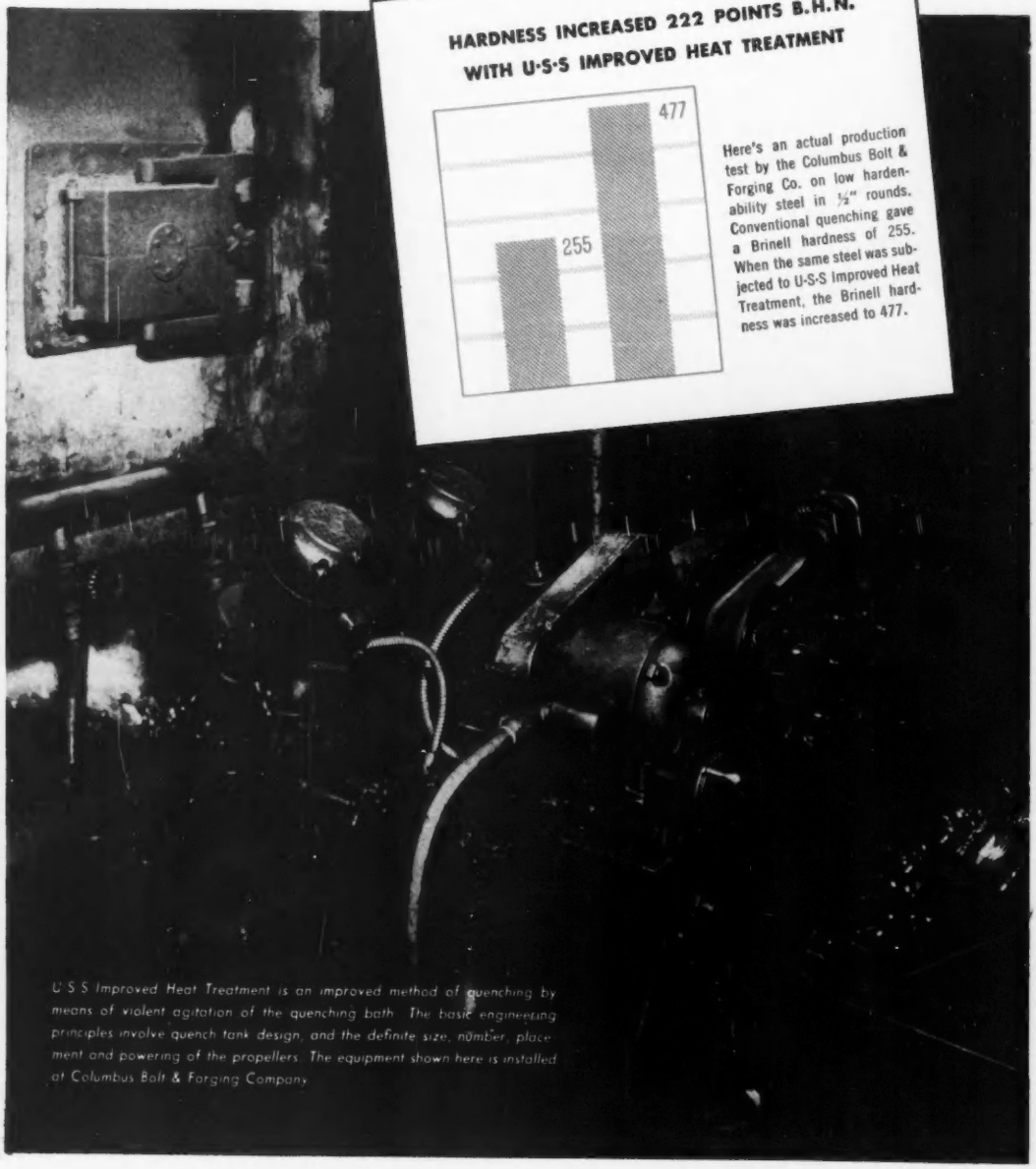
Company_____

Business Address_____

City_____ Zone____ State_____

678

HOW TO GET THE MOST OUT OF
—keep a sharp eye



HARDNESS INCREASED 222 POINTS B.H.N. WITH U·S·S IMPROVED HEAT TREATMENT

Here's an actual production test by the Columbus Bolt & Forging Co. on low hardenability steel in ½" rounds. Conventional quenching gave a Brinell hardness of 255. When the same steel was subjected to U-S-S Improved Heat Treatment, the Brinell hardness was increased to 477.

U S S Improved Heat Treatment is an improved method of quenching by means of violent agitation of the quenching bath. The basic engineering principles involve quench tank design, and the definite size, number, placement and powering of the propellers. The equipment shown here is installed at Columbus Bolt & Forging Company.

THE ALLOY STEEL YOU'RE GETTING on quenching methods

TODAY, as critical alloying elements become scarce, all users of alloy steel are faced with the necessity of getting the most out of the steel they're receiving.

In most cases, this puts the problem squarely up to the heat-treater. Better heat-treatment methods can often do the job.

If you encounter difficulties, don't be too quick to blame the steel or the heating practice. The answer may be better *quenching* methods. More specifically, your problem might be solved with U·S·S Improved Heat Treatment — a superior quenching technique developed by United States Steel.

U·S·S Improved Heat Treatment extracts heat rapidly and *evenly* from every part of the material's surface. This treatment assures accurate timing, allowing removal of the material from the quenching bath while a certain amount of residual heat is present. Elapsed time from quench to tempering treatment is held to an absolute minimum. This not only improves mechanical properties; it also reduces cracking. And, this quenching method improves machinability by minimizing the formation of free ferrite in hypo-eutectoid steels.

The use of this quenching process is available to you without charge.

United States Steel does not manufacture or sell heat-treating equipment, but our metallurgists will be glad to analyze your heat-treating methods and make suggestions that may give you more uniform hardness, less rejects and less retreatment.

UNITED STATES STEEL COMPANY, PITTSBURGH
COLUMBIA STEEL COMPANY, SAN FRANCISCO
TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM
UNITED STATES STEEL SUPPLY COMPANY
WAREHOUSE DISTRIBUTORS, COAST-TO-COAST
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

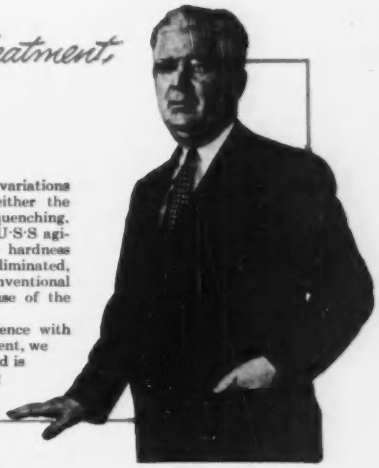
Comments on U·S·S Improved Heat Treatment

by Mr. R. E. Christin, Chief Metallurgist
Columbus Bolt & Forging Co., Columbus, Ohio

"Quenching is a process often neglected in heat treatment. We feel it is just as important (if not *more* important) than any other phase of heat treatment. There is a tendency to concentrate too much on the heating—and lay too much blame for failure to the heating—when proper quenching could produce the objectives desired. Heating, even in the ideal environment, can be inadequate if quenching is faulty.

"Before we installed U·S·S Improved Heat Treatment, we occasionally encountered hardness variations in the as-quenched condition. These variations were loosely attributed to either the steel, or the heating or the quenching. However, after adopting the U·S·S agitated quench process, these hardness variations were practically eliminated, obviously indicating that conventional quenching was the chief cause of the hardness variations.

"After seven years' experience with U·S·S Improved Heat Treatment, we are convinced that this method is the answer to most hardening problems."



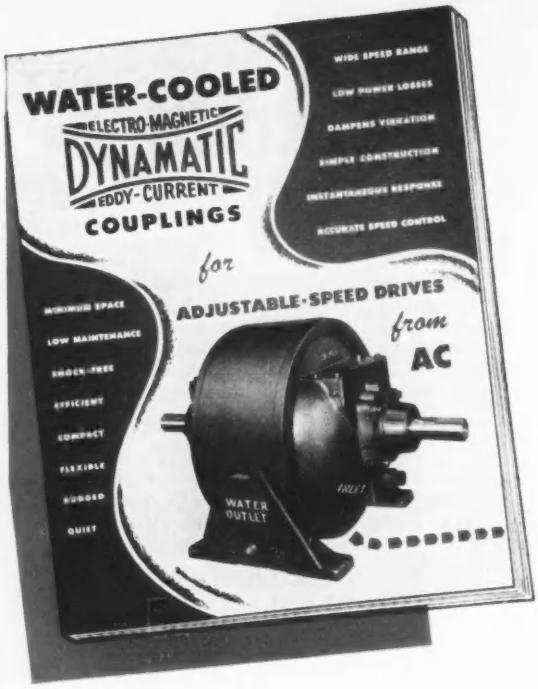
Carilloy Steels

ELECTRIC FURNACE OR OPEN HEARTH

COMPLETE PRODUCTION FACILITIES IN CHICAGO OR PITTSBURGH

1-939

UNITED STATES STEEL



If you want the last word on Eddy-Current Couplings, write for your copy of this new booklet

Eddy-Current Couplings provide a long list of desirable characteristics including instantaneous response, infinitely adjustable speed control, wide speed range, quiet operation, low power losses, low maintenance cost—without mechanical contact between the driving and driven members—and entirely from AC power.

If you are interested in this modern method of speed control, write on your company stationery for this comprehensive booklet. It presents a down-to-earth explanation of the Eddy-Current Principle, and the operation of the Dynamatic Eddy-Current Water-Cooled Coupling.

DYNAMATIC® **CORPORATION** • **KENOSHA WISCONSIN**

Subsidiary of **EATON MANUFACTURING COMPANY,** **Cleveland, Ohio**

Dynamometers • Oil Well Draw-Works Brakes • Adjustable-Speed Couplings • Eddy-Current Brakes
Ajusto-Spedes • Shovel Clutches • Press Drives • Lift Truck Clutches • Electronic Controls

Reynolds
ALUMINUM REPORTER
A SERVICE TO INDUSTRY ON ALUMINUM USES AND DEVELOPMENTS

LOUISVILLE 1, KY. NUMBER 5

REYNOLDS OPERATING MICHIGAN AIR FORCE PLANT

Aluminum Right for Hardware Fittings

Aluminum offers many qualities that add both appearance and durability to hardware fittings. It also is more economical than any other non-ferrous metal and is more desirable from several standpoints.

Aluminum hardware has a lasting, bright natural finish that requires no protective coating. And if special decorative effects are required, aluminum takes an extremely wide variety of finishes. In addition, aluminum offers strength with less weight for handling and shipping.

The hinge illustrated above is a good example of how the extrusion process can cut costs and simplify production of aluminum hardware. The undrilled piece is a section of an aluminum extrusion which is cut to specified hinge lengths. The tubular edge is then milled for mating hinge leaves. When screw holes are drilled and counter-sunk, hinges are ready for assembly with an aluminum pin. Decorative knobs made from aluminum screw machine stock are optional.

The extrusion process is also ideal for combining several elements into a single unit to eliminate excessive and costly assembly operations. A new 16 mm., sound-color movie, "The Shape of Things to Come" describes a variety of actual applications and the extrusion manufacturing process. Running time is 30 minutes. This movie is available without charge for individual showings, when requested on business letterhead. Write to Reynolds Metals Company, Motion Picture Dept., 2576 South Third Street, Louisville 1, Kentucky.

World War II Aluminum Extrusion Center now U.S.A.F. Manufacturing Methods Development Plant

The Reynolds Metals Company has taken over the management of the U.S. Air Force's Manufacturing Methods Pilot Plant at Adrian, Michigan.

Reynolds will operate the 20-million dollar government-owned facility without fee or profit to develop new forging and extrusion techniques and to prove theoretical designs for products in *all* metals.

The plant is available to any industry or government agency interested in development work on processes of either military or non-military interest.

A number of large manufacturing firms have already contracted for the use of Adrian plant and its development facilities.

The Curtiss-Wright Aircraft Company, in conjunction with the Air Force, has developed a new method for producing a hollow steel propeller by an improved extrusion technique. A 200 pound, 10-foot propeller blade tube is produced from a white-hot, 400 pound chrome-nickel molybdenum steel billet in minutes. This process, which is accomplished in three major stages, eliminated time-consuming operations of welding together, brazing and forming of two specially-processed flat plates which weigh 750 pounds before machining to produce the same size blade. At the same time this new process improves blade quality and strength-weight ratio.

Equipment in the plant consists of 16 hydraulic extrusion presses, largest of which is of 5,500 ton capacity. Others are of the 3,850-ton, 2,750-ton, and 1,650-ton capacity sizes. In addition, four German forging presses from the I. G. Farben Industries, with capacities, of 660—2,200—7,700 and 16,500 tons are now installed.

The factory building itself contains 700,000 square feet and is situated on a 73 acre site. No actual production will take place in the plant under the contract with Reynolds, except in the case of national emergency.

With the facilities at this new plant, Reynolds will promote constant research and development of new production methods.

For more information, write for copy of the new 24-page brochure detailing Adrian facilities and how they can serve you. Address your letter to Reynolds Metals Company, 2576 South Third Street, Louisville 1, Ky.

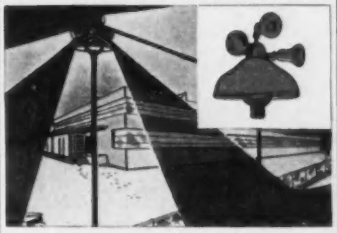
Die Cast Lighting Fixtures for Outdoor Use Afford Greater Defense Plant Security

Plants throughout the country, requiring dependable outdoor lighting systems for military security reasons, are turning to the use of die cast aluminum lighting fixtures.

The light weight, rust-resistant qualities of aluminum provide safe and economical operation of lighting systems that must function at peak efficiency despite exposure to severe climatic conditions.

Cast aluminum cluster lighting fixtures of this type are made by the Killark Electric Mfg. Company of St. Louis, Missouri. They have been proven in use for flood or spot systems on farms and factories, billboards and parking lots.

These fixtures make daylight out of darkness, and help put the permanence needed in outdoor lighting systems. Killark also manufactures a fully complementing line of aluminum light shields, wiring troughs, acorn fittings, extensions and adaptors. All are made of aluminum, assuring years of dependable performance.



Directed beams with multiple fixture

Check the many advantages of die cast aluminum—minimum machining, fast production, durability, low cost—and see if it can help in your production problems. Call on the complete staff of Reynolds technicians for help in your designing. Look for the Reynolds office listed under "Aluminum" in your classified telephone directory. Or, write the Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

MORE INTERESTING NEWS ABOUT ALUMINUM ON NEXT PAGE

Printed in U. S. A.

Fabricating Service Speeds Production, Saves Scrap

Carting 5-inch rockets to Corsair, Skyraider for loading

Aluminum Rocket-fin Example of Service to Industry

Aluminum rocket fins guiding 5-inch rockets now being used by the air forces in Korea are among the many production items Reynolds Fabricating Service is engaged in producing for the Armed Forces. In the photo above, crewmen of the Navy and Marine Corps are shown preparing to load these effective missiles aboard war-planes for use against the enemy.

Although Reynolds is doing the basic mass-fabricating on the components, considerable amount of the assembly (including spot welding, seam welding, servicing and packaging) is being shared on a sub-contract basis with other aluminum fabricators under the Reynolds "Share-the-Work" plan.

This is only one example of the valuable service made available to manufacturers through the use of the Parts Fabricating Service. Formed or partially-formed parts are delivered to the manufacturer ready for finishing and assembly, resulting in scrap savings averaging 30% and valuable time gains.

Blanked parts eliminate costly tie-up of shipping and stockroom space . . . save in scrap handling and storage, make scarce material available for instant remelting.

The manufacturer gets exact number of parts needed and is assured of maximum efficiency and a steady flow of inspected parts in any quantities or stage of completion desired.

Reynolds Aluminum Parts Fabricating Service is the *complete* service with equipment for shearing, forming, tube bending, roll forming, roll shaping, riveting, welding and finishing.

Reynolds is set up to work in co-operation with both large and small manufacturers. This program is directed toward combining the resources of all of the nation's businesses to supply the needed production for today's large volume of defense orders.

For complete information on how the Reynolds Parts Fabricating Service can help you, write for the free booklet, "Pounds of Parts...instead of Pounds of Metal". And for assistance on *special* aluminum fabricating problems, call the Reynolds office listed under "Aluminum" in your classified telephone directory. Or, write Reynolds Metals Company, 2065 So. Ninth St., Louisville 1, Kentucky.

Aluminum Chicken-Blinders Cut California Cannibalism

Our West Coast office has forwarded to us one of the most unusual aluminum items we have ever run across. In father's day, horse-blinders were common equipment, but now we have, believe it or not, *chicken-blinders!*

Poultry growers have long known that chickens are cannibalistic. The sight of fresh blood will incite large flocks of fowl to the extent that they turn and tear their kind to pieces. On large ranches, thousands of chickens have been killed at one time.

Chicken-blinders, stamped from sheet aluminum and fastened to the beak with a cotter pin, prevent the bird from seeing directly ahead and eliminates the urge to battle.

Although there are blinders made of other material on the market, the aluminum type has proven most satisfactory in service. The light weight combined with its non-corrosive qualities make it ideal for use under the type of conditions found in poultry yards.

Aluminum Foil Meets Military Packaging Specifications

Barrier Material, Grade A and Acetate Bonded Wraps Ready for Many Defense Purposes

Reynolds Aluminum Foil has moved from the pantry shelf to the shipping line in defense production plants throughout the country. The Reynolds Metals Company has turned the production of the valuable and versatile aluminum sheeting into packaging material that will meet the government's strictest military packaging requirements. The company has prepared a booklet, available upon request, containing samples and complete specifications for these requirements.

Aluminum Foil by itself and in combination with other materials answers thousands of packaging problems. From powdered milk to aircraft engines, wrenches to rifles, the moisture-proof, corrosion-resistant qualities of aluminum provide the ideal wrap for protective shipment.

Acetate-Bonded Aluminum for Soluble Coffee, Powdered Milk, Sugar, Tea, Salt, Concentrates, Assault Rations, etc. Printed, pliable material for high-speed packaging. Takes firm, impenetrable heat seal...moisture-vapor proof, holds flavor, protects against contamination and light rays. Widths from 2" to 25"—takes reverse printing.

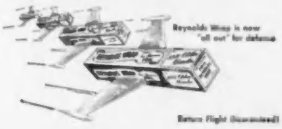
Barrier Material for Accessory Packaging. Very flexible foil-on-kraft with waterproof laminant and clear Vinyl Heat Seal Coating. For small packages — medical supplies, cigarettes, bandages, ration material and other quartermaster applications. Standard widths 24" and 36" for own printing and automatic packaging. Or write for data on preformed printed packages.

Barrier Material for Bags, Interior Packaging is a heavier version of above for larger bags, rougher handling. Also meets basic material specifications for a Grade A non-corrosive wrapping material. Tough and tear-resistant, supplied in same widths and style as above.

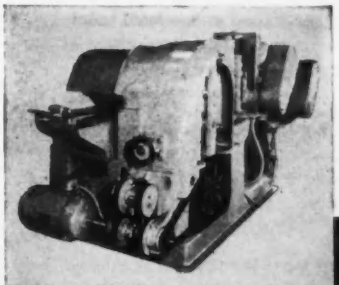
Barrier Material for Method II Packaging. Triple lamination of foil, cloth and heat-sealing plastic sheet. Designed for highest degree of moisture-vapor and physical protection—the Method II (carton-barrier-carton) application with desiccant. Standard 36" width.

Aluminum Foil Grade A Wrap. For odd shapes, eliminates taping or tying, saves time in packing. Under certain moist atmospheric conditions, protects against galvanic and contact corrosion of metal parts. In .001", .0015", .002" and .003" gauges.

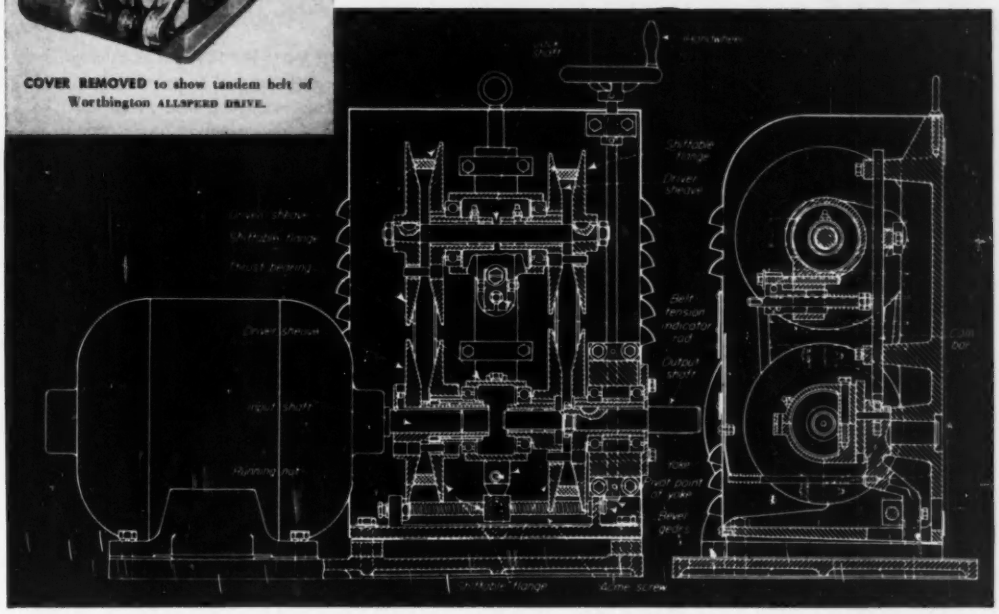
Reynolds Technical Service is at your disposal with extensive research facilities for development of new materials and packages. For free copy of booklet "Barrier Material for Military Packaging," contact your Reynolds Sales Office or write on business letterhead to Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.



Two Belts Take Up Less Room Than One!



COVER REMOVED to show tandem belt of Worthington ALLSPEED DRIVE.



CROSS-SECTIONAL views of Worthington ALLSPEED MOTOR DRIVE.

New variable speed drive gives wider speed variation in limited space

And belt *replacement* is reduced, too!

Those are two of the reasons why the new Worthington ALLSPEED DRIVE is your best specification for variable speed control.

The "tandem-belt" design gives a greater range of instantaneous, stepless variations than the single belt used in other variable speed drives. And it permits using a *narrower* belt than other drives—this means less wear from flexing and compression, longer life.

Other advantages: Easy belt replacement—don't have to dismantle the unit • Automatic positive belt tensioning • All wearing parts bronze-bushed • All ball bearings shielded and life-lubricated • In-line input and output shafts • Can be run in either direction.

MODELS TO SUIT YOUR DESIGN

Six sizes from 1-15 hp; up to 16-1 range of variation.

Covered or skeleton models—or supplied less any parts, such as without shifting parts for attachment to your shifting mechanism.

With or without built-in motor—standard NEMA Frame 1750 rpm motor.

Upright or horizontal frame.

Extended control yoke available.

Send coupon for Worthington Allspeed Drive bulletins AS-1600-B3 and AS-1600-B4. Worthington Pump and Machinery Corporation, Worthington Allspeed Drive Division, Holyoke, Massachusetts.

WORTHINGTON

AS.1.3

THE GOOD RIGHT HAND OF INDUSTRY

POWER TRANSMISSION: sheaves, V-belts, variable speed drives

PUMPS: centrifugal, power, rotary, steam

AIR COMPRESSORS: water-cooled, air-cooled

Worthington Pump and Machinery Corporation
Worthington Allspeed Drive Division
Holyoke, Massachusetts

Please send bulletins AS-1600-B3 and AS-1600-B4 on Worthington Allspeed Drive.

Name.....

Company.....

Address.....

SAVE metal

SAVE man-hours

SAVE money

By using Gramix parts, die-pressed of powdered metal mixtures, in place of machined parts in products, you can make three important savings—savings that are becoming more vital with every day that passes.

GRAMIX PARTS SAVE METAL. They are made with minimum scrap and waste . . . pound-for-pound more pieces can be produced from Gramix than can be obtained from solid or bar stock that is in tight supply today.

GRAMIX PARTS SAVE MAN-HOURS and machining time because, they are die-pressed to tolerances as close as .0005" . . . the machining time saved can be made available for defense weapon production.

AND, GRAMIX PARTS SAVE MONEY because in quantity lots they can be produced at considerable less cost than identical machined parts. Then too, Gramix parts are oil-impregnated for self-lubrication thus eliminating the need for servicing. Add up the advantages and you'll see why it'll pay you to go to Gramix . . . the leader in the powdered metal field. Write us for the full story.

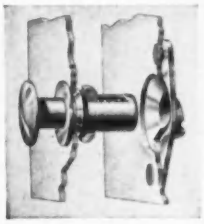
with GRAMIX® parts

84-A

THE UNITED STATES GRAPHITE COMPANY

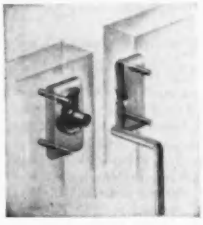
DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

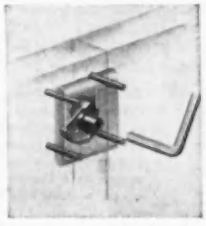
3 ways to save on assembly costs



QUICK-LOCK For fastening removable access doors and panels. Because of its ease of installation, QUICK-LOCK is ideal for assembling removable panels. A 90° turn locks it in place. Stud is self-ejecting when unlocked; visual inspection shows whether fastener is locked. Spring loading takes initial load; solid supports carry increased load. Available in a wide range of sizes.

SPRING-LOCK One-piece fastener for blind holes has load-carrying steel spring wire. Spring steel arms lock fastener securely, prevent loosening under vibration. SPRING-LOCK will work with varying panel thicknesses, locks with a twist of the wrist. SPRING-LOCK is now available in high-impact plastic. The molded design permits heads to be made in various shapes for refrigerator shelf supports, washer knobs, brackets. Available in a wide variety of shapes and sizes, and also in custom designs.





ROTO-LOCK Serrated, tapered cam is engaged by formed lug as fastener is locked. Cam action draws panels together tightly, insures locking even under conditions of misalignment. Opens easily for demounting. ROTO-LOCK carries heavy tension and shear loads; can be used for air and water-tight seals; recesses completely into panels. Solidly built without springs or delicate mechanical parts, unaffected by arctic temperatures or field service.

Simmons Fasteners are widely used in refrigerators, washing machines, electrical equipment, electronic assemblies, prefabricated portable shelters, coolers, demountable furniture. Every Simmons Fastener is a service-proved design with a long record of assembly-cost saving in many industries.

If you are interested in cutting your costs, turn to Simmons Fasteners—the fasteners with *uses unlimited*. Write for samples and catalogs today.

SIMMONS FASTENER CORPORATION
1751 North Broadway, Albany 1, New York

Simmons
QUICK-LOCK
SPRING-LOCK
ROTO-LOCK

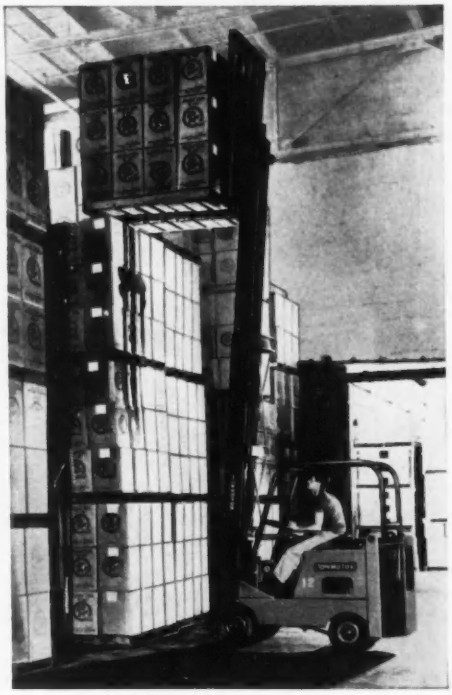
Close-quarter operation with 3½ ton loads!

STRONG, DEPENDABLE

TDA BRAKES

PROVIDE EFFECTIVE CONTROL!

Handling bulky loads in close quarters calls for powerful, positive braking! That's why Towmotor Corporation equips its lift trucks with safe, dependable TDA Brakes. The Towmotor industrial lift truck for materials handling has a variety of applications. It loads, transports and stores single pieces of bulky, heavy material or unit loads of small individual pieces. An extra-large TDA Brake is used for stopping, for holding the load on steep grades and for holding the truck stationary during loading and unloading operations. The TDA Brake has proved itself safe and effective under all conditions.



WHATEVER YOUR BRAKING PROBLEM—TAKE IT TO TDA BRAKE DIVISION!

In almost every industrial machine operation, control of rotation is an important consideration. And, for the most part, this rotation must be controlled and stopped by brakes. That's why more and more manufacturers are turning to TDA Brake Division for a solution to the important—and sometimes difficult—problem of finding the properly designed brake to do an effective, dependable job. They know the vast experience of TDA's brake engineers means careful analysis of the job to be done. They know, too, that the ultimate result of this analysis will be a brake that has been specifically designed and built to meet the most exacting operating requirements. Mail the coupon below for information on how TDA Brake Division can improve your product's performance—reduce your customer's maintenance expense.

Here Are A Few Of The Many Products Which Can Be Equipped With TDA Brakes

Centrifuges • Compressors • Conveyors • Cranes Cream separators • Diesel hook-ups • Dry cleaning machinery • Extractors • Hoists • Industrial electric trucks • Lathes (automatic) • Looms (textile) • Lumber mill machinery • Machine tools • Materials handling equipment • Motors • Packaging machinery • Paint mixers • Press brakes • Printing presses • Rolling mills • Shears • Warpers (textile) • Welding positioners • Winches • Automotive • Farm equipment Earth moving equipment • Construction equipment Public transportation

IF IT ROTATES WE CAN BRAKE IT

TDA BRAKE DIVISION—DEPT. A-4
ASHTABULA, OHIO

Please mail brake information on these applications:

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

TIMKEN *Detroit* BRAKES
TDA BRAKE DIVISION
THE TIMKEN-DETROIT AXLE COMPANY
ASHTABULA, OHIO.
The Accepted TDA Standard
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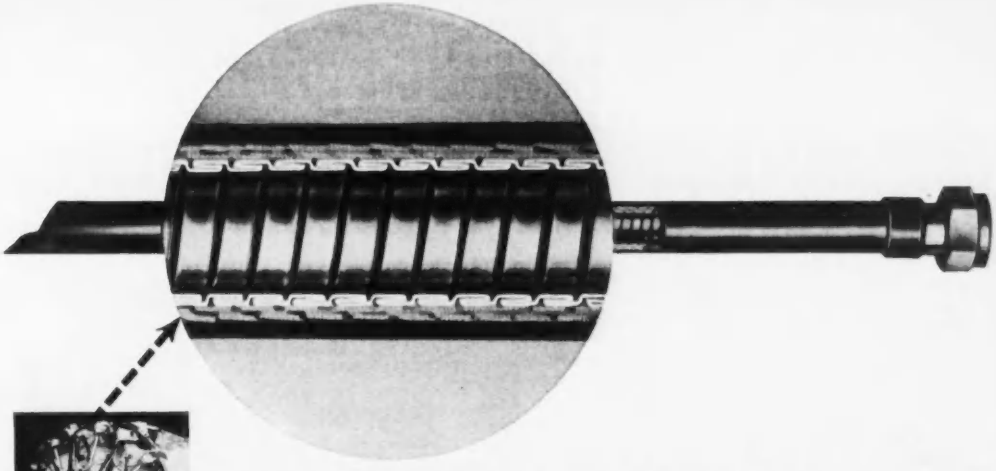
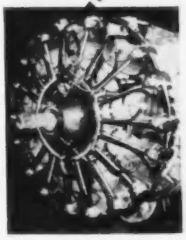




WHY AIRCRAFT SHIELDING NEEDS THIS TIGHT-FITTING JACKET OF "FAIRPRENE"*

New "Teflon"† Coated Glass Fabrics, Tapes and Laminates

Outstandingly versatile new material for electrical industries. Made from woven glass fabrics coated with polytetrafluoroethylene.

Although, at present time, "Teflon" products are subject to allocation by the National Production Authority, limited experimental quantities are available.

A FEW PROPERTIES: high and low temperature resistance (may be used continuously at 200°C.), fine electrical properties, extremely tough, unaffected by all known chemicals, excepting molten alkali metals under normal conditions, zero water absorption, unaffected by weathering, good non-sticking characteristics.

For further information, clip and mail coupon below. †REG. U. S. PAT. OFF.

A moisture-proof molded jacket of tough Du Pont "Fairprene" gives lasting protection to Aircraft Shielding Conduits manufactured by the American Metal Hose Branch of The American Brass Company. Designed for aircraft-engine spark-plug leads, these conduits must withstand abuse, resist aging, and function without interference from moisture or metallic contact.

The American "HTCD" shielding conduit pictured above has surpassed requirements set by rigid Air Force tests, and won the acclaim of airline operators for its long life. "Fairprene" plays the vital role of protecting the double wire braids over the four-wall flexible metal core. It resists abrasion . . . withstands vibration . . . won't deteriorate in oil or gasoline . . . remains tough and flexible at extremely high or low temperatures. The "Fairprene" is molded directly onto the metal conduit to form a tight, uniform, lightweight covering that needs no metal clamps on the ends.

For coverings, in diaphragms, and in hundreds of other industrial applications, Du Pont "Fairprene" is preferred for its outstanding properties. It resists aging in air or oxygen, has low permanent set and drift, retains it properties under severest conditions.

Technical Help for You

Du Pont engineers are eager to help you evaluate "Fairprene" for designing new products, or for improving your present products or manufacturing methods. They'll gladly work with you in engineering special grades of "Fairprene" to meet your specific needs. For prompt assistance, fill out and mail the coupon below. Do it today!

DU PONT "FAIRPRENE"

synthetic elastic compositions

"ENGINEERED TO DO YOUR JOB BETTER"

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

**"FAIRPRENE" is Du Pont's registered trade mark for its line of products made from synthetic elastomers available in the form of coated fabrics, sheet stocks without fabric insert and adhesives.*

E. I. du Pont de Nemours & Co. (Inc.)
Fabrics Division
Empire State Building, New York 1, N. Y.

- ☐ I am interested in Du Pont Technical Service.
- ☐ Please send me booklet "'FAIRPRENE' synthetic elastic compositions."
- ☐ Please send me Technical Bulletin "'TEFLON' Coated Glass Fabrics."

Name_____ Title_____

Firm_____

Address_____

This combination gives you 3 PLUS-performance features

IN ONE ASSEMBLY OPERATION...

the famous SHURE STAKE Tool* has now been adapted to install also the new T & B Self-Insulated Sta-Kon Terminals†

For terminal-to-wire assemblies that are quickly and easily made . . . and stand up under the toughest service conditions . . . just close the jaws of these new SHURE STAKE Tools on T & B Self-Insulated Sta-Kon Terminals. You build these *three* service advantages into your products, in a *single* low-cost operation:

1. Electrically sound, mechanically strong joint. (Unique, time-tested SHURE STAKE toggle principle builds pressure of one hand up to 2000-pound staking force. *Ordinary* tools exert only 800-pound pressure.)

2. Firm gripping of wire insulation within insulated terminal body. (SHURE STAKE Tool closes both wire-gripping and insulation-gripping ends of terminal simultaneously.)

3. Terminal insulation that prevents shorts in close quarters—*without* an extra insulating operation. (Insulation is positively anchored in place when terminal is shipped—*remains* positively anchored during assembly and in service.)

RESULTS ARE SURE

With SHURE STAKE Tools, you get a top-quality assembly job *every time*. Once the jaws have started to close, they *can't* be reopened till *full* staking pressure has been applied.

And . . . it's a cinch to be sure you're using the right *size* tool. SHURE STAKE Tools, like Self-Insulated Sta-Kons, are *color-coded* for size. Just look for the terminal color on the tool handle!

Three tool designs meet all assembly requirements. WT-143 handles RA and RB terminals; WT-144 installs RC size; WT-141 is adjustable for all three sizes.

*Patents Pending †Patented

THERE'S A T&B ENGINEERED PRODUCT for every wiring job in the complete T & B line of fittings for all conductors and raceways.

Manufacturers of Electrical Fittings since 1899
Originators of self-insulated solderless terminals in 1935

ENGINEERED RIGHT... DISTRIBUTED RIGHT... *These new SHURE STAKE Tools for Self-Insulated Sta-Kon Terminals are typical of the many T & B quality products recently re-designed to give you outstanding performance at lowest cost. Like all T & B products, they're furnished exclusively through local T & B distributors under the T & B plan.*

THE THOMAS & BETTS CO.

INCORPORATED
16 Butler Street, Elizabeth 1, New Jersey

Our Field Design Engineers are ready to help you on special fittings problems. Ask your nearest T & B distributor to arrange to have one get in touch with you.

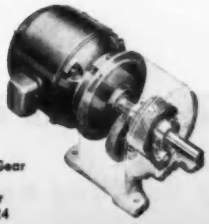
No one speed-reducer solves every reduction problem

That's why LINK-BELT builds all 3

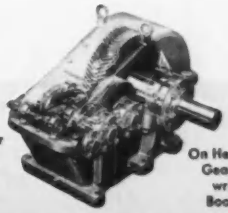
WHETHER it's a helical, a herringbone or worm gear drive that best fits your needs—you get an unbiased recommendation, an incomparable product from your Link-Belt power transmission engineer.

That's why Link-Belt builds all three; has no axe to grind. You can be sure you get the one that suits all your requirements for ratio, space, shaft position, shock loading and many other factors. Precision-engineered for quiet, economical power transmission, all Link-Belt drives will give you long service under the toughest operating conditions.

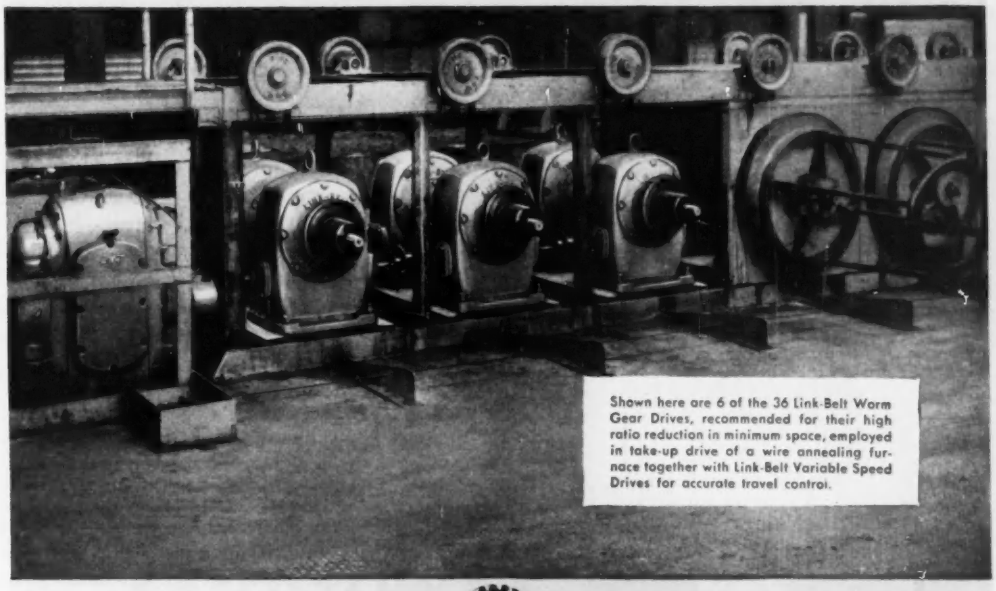
On Worm Gear Drives write for Book 2324



On Gearmotor and Helical Gear Drives write for Book 2247



On Herringbone Gear Drives write for Book 2419



Shown here are 6 of the 36 Link-Belt Worm Gear Drives, recommended for their high ratio reduction in minimum space, employed in take-up drive of a wire annealing furnace together with Link-Belt Variable Speed Drives for accurate travel control.

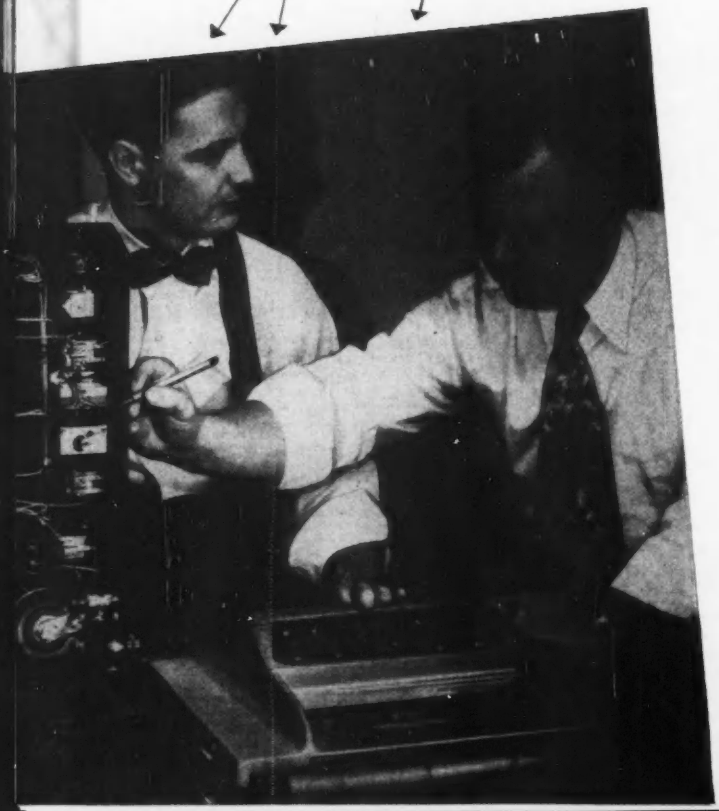
LINK-BELT
ENCLOSED GEAR DRIVE

12,230

LINK-BELT COMPANY: Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Springs (South Africa). Offices, Factory Branch Stores and Distributors in Principal Cities.

Bell and Howell find MICRO complex design requirements

Eleven MICRO precision switches prove their worth as "a principle of good design" in the Microfilm Recorder— made by Bell and Howell, sold by Burroughs



Design and construction of this modern business machine . . . the Bell and Howell Microfilm Recorder . . . demanded the utmost in precision equipment throughout. This included snap-action precision switches that could be depended on for almost incredibly accurate, sensitive, fast operation.

MICRO SWITCH engineers assisted Bell and Howell in the selection of the eleven switches required for the exacting demands of the recorder. Some of these MICRO units perform functions of extreme delicacy; others must withstand high surge currents; still others are called upon to open and close through 100,000 or more cycles daily.

If you are faced with a product design problem involving a precision switch application, it will pay you to acquaint yourself with the engineering assistance MICRO SWITCH can offer. Call or write the branch office nearest you.

A DIVISION OF

Precision Switches meet in Microfilm Recorder!

The **MICRO Type "W" Precision Switch . . .** sensitive enough to "feel" the presence of even an extra thickness of tissue paper in the Bell and Howell Microfilm Recorder!

The extreme sensitivity of this MICRO Type "W" precision switch commended it to Bell and Howell engineers as a component for the Microfilm Recorder. More than half the MICRO units used in the Recorder are of the "W" type.

The MICRO "W" actuator is a pivoted steel lever to which is attached a beryllium copper overtravel leaf spring. The flat lever actuator may be operated by cams or slides.

This MICRO precision snap-action switch is one of nearly 5000 types designed to meet specific applications. Should none of these meet your requirements, MICRO SWITCH Engineering can help with the solution of your problem.

MICRO MS SWITCH

FREEPORT, ILLINOIS

MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

Try these for ideas
. . . for savings, too!

● In today's stepped-up defense production, the ways we can help you on your bellows assemblies needs will make important savings for you.

If you're looking for ideas, Sylphon bellows assemblies offer *plenty*. They open and close valves, dampers, etc., absorb expansion, provide packless construction—have a whole list of practical uses. The diagrams show a few typical uses—where there's a design problem involving control of temperatures or pressures.

Or, take design and development. You may have a problem similar to one we have solved for another customer. You may need assemblies for a specific application. Whatever your need, we'll work with you to develop *exactly* what you require.

On production—you can confidently turn over the complete job to us. You're relieved of production worries. Our skilled personnel and complete facilities can turn out your requirements, simple or complex, on schedule.

Talk over your requirements with us. As specialists in this field for half-a-century, our experience can be more valuable than ever to you.

Wide range of metals and sizes. Send for information. Ask for idea-packed Catalog NP-1200.

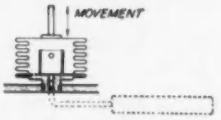


Fig. 1 Thermostatic Motor—This type of assembly is widely used in temperature regulators, etc., where a thermostatic charge is confined in the bellows and where a valve, switch, damper, etc. is to be operated in response to temperature changes.

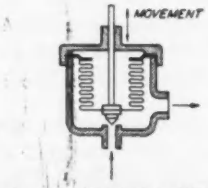


Fig. 2 Packless Construction—Illustrating packless valve construction. Same principle used to seal stem movement or adjustment in many types of apparatus.

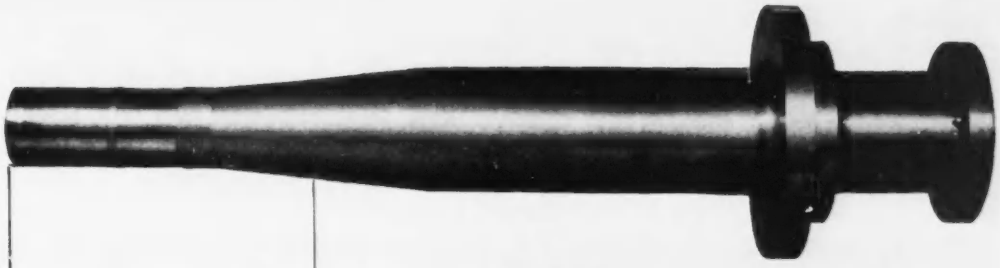
TEMPERATURE CONTROLS

FULTON SYLPHON
DIVISION
Knoxville 4, Tenn.

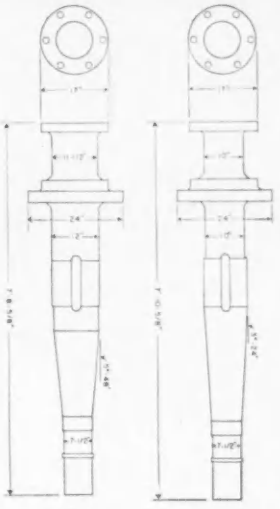
Robertshaw-Fulton CONTROLS COMPANY

BELLOWS ASSEMBLIES • BELLOWS DEVICES

BRIDGEPORT THERMOSTAT
DIVISION
Bridgeport 1, Conn.



DUCTILE IRON
replaces steel
IN SHAFTING
finished cost { 28% less than that of forged steel shafts



DUCTILE IRON FORGED STEEL

COOPER-BESSEMER CORP., Mt. Vernon, Ohio, adopted ductile iron generator shafts to replace those of forged steel. Corresponding changes in design and dimensions are shown above.

Ductile iron provides unusual advantages. Its tensile strength runs between 83,000 and 94,000 p.s.i. as cast, on test bars cut from a full diameter extension on the small end. Unlike forged steel, which is a product obtained from outside sources, ductile iron shafts are cast as well as machined in the company's own plant. They make possible a low finished cost . . . 28% less than that of a forged steel shaft made to the dimensions shown above.

DUCTILE IRON is a cast ferrous product that combines the *process advantages* of cast iron along with many of the *product advantages* of cast steel.

In less than two years, ductile iron has attained wide acceptance because it offers excellent castability, high mechanical properties and good machinability. Parts cast in ductile iron show superior strength, high modulus and excellent shock resistance.

Typical Current Applications: Axle housing for road machinery, steel rolling mill bearings, chain swivels, diesel cylinder heads, grates, pipe fittings, rails, etc.

AVAILABILITY: Send us details of your prospective uses, so that we may suggest a source of supply from some 100 authorized foundries now producing ductile iron under patent licenses. Request a list of available publications on Ductile Iron . . . mail the coupon now.

The International Nickel Company, Inc.
Dept. P.E., 67 Wall Street, New York 5, N. Y.

Please send me a list of publications on: **DUCTILE IRON**

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THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

Designer's

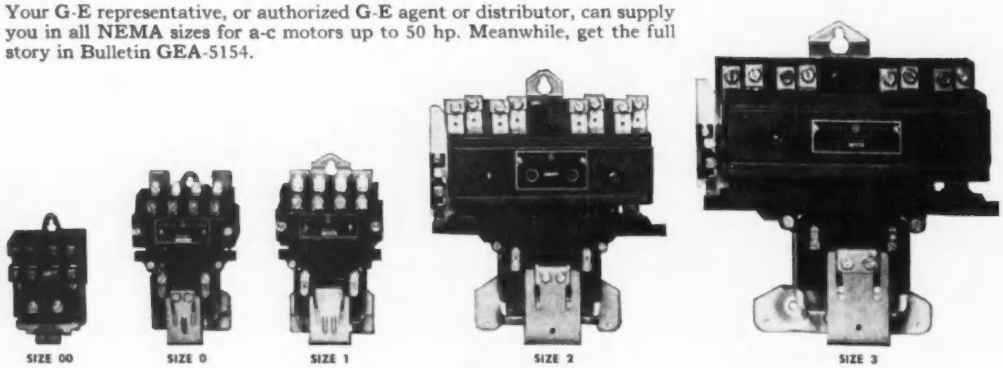
Simplified design makes them easier to install and service!

No doubt about it! Simplified design, for faster, easier installation and maintenance, has made these General Electric magnetic contactors—heart of the whole G-E line of starters— a big hit with machinery manufacturers. For instance:

- Terminals, easily accessible from the front, have large pan-head or slotted hex-head screws to speed wiring of either stranded or solid wire.
- Main poles in the three smaller sizes—and interlocks in all sizes—can be changed from normally open to normally closed without need of extra parts, facilitating quick changes and reducing your inventory of "specials."
- Extra two-circuit interlocks—with interchangeable normally open or normally closed contacts—can be quickly added to either side of contactor, need no drilling, no extra accessories.
- Arc hood is held in place by two easily-removed captive screws to expose terminals completely for inspection and maintenance.
- Three-point keyhole slots in rear of contactor make panel mounting a simple matter, and insulated aluminum base permits mounting on all types of panels.
- NEMA mounting dimensions mean maximum interchangeability.

Your G-E representative, or authorized G-E agent or distributor, can supply you in all NEMA sizes for a-c motors up to 50 hp. Meanwhile, get the full story in Bulletin GEA-5154.

MAGNETIC CONTACTORS

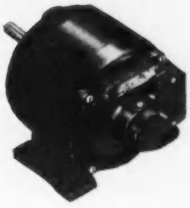


GENERAL ELECTRIC

Digest

PRODUCT HIGHLIGHTS

A FULL LINE OF FHP MOTORS TO MEET YOUR NEEDS



Fhp machine-tool motor

This polyphase induction motor, specifically designed for frequent start-stop duty on machine tools, is one of a wide variety of G-E standardized fractional-hp motors available to meet your design needs. This complete line includes, for general applications, polyphase induction, d-c, capacitor-start, and split-phase motors, as well as gear and unit-bearing motors and a broad selection of definite-purpose motors for more limited applications. Specify one of these G-E motors in your next design. They're known to be preferred by your customers, play a big part in selling your product. See Bulletin GEA-5174.

SPEED, ACCURACY AND FLEXIBILITY —ALL IN ONE!

Photoelectric recorder

Besides measuring a-c and d-c volts and amperes, this versatile General Electric photoelectric recorder provides a quick, accurate record of almost anything that can be measured with an indicating instrument—temperature, speed, pressure, thickness, light, and vibration. In deflection and potentiometer types, for portable use or semi-flush mounting, it features chart speeds from ½ inch to 72 inches per minute, sensitivities as low as 1.0 microampere full scale, and response periods as fast as ⅕ second for full-scale deflection. See Bulletin GEC-254.

HOW TO SIMPLIFY "BUILDING-IN" THE RIGHT SPEEDS

Adjustable-speed manual

This 26-page illustrated manual—a worthwhile addition to your reference file—covers the entire subject of adjustable-speed drives, including their economic and engineering benefits and the points to consider in their selection. Especially helpful is a concise description of available General Electric *packaged* adjustable-speed drives, plus a well-organized table that summarizes the ratings and performance features of each drive. See Bulletin GEA-5334.

NOW— MOTOR SELECTION AND APPLICATION SIMPLIFIED

NEW G-E "SHOW-HOW" COURSE helps train your workers

Of special interest to designers is this new General Electric Motor Selection and Application Course—timed to meet today's need for more motor "know-how" by your personnel. A G-E More Power to America program, it shows simply and clearly how motors work, types now in use, how to select and apply them to specific jobs. Kit includes instructor's manual, nine slidefilms with records, student review booklets, and sturdy carrying case. Ask your G-E representative for a free copy of the manual. Meanwhile send for Bulletin GEA-4938-16 describing the course in detail.

General Electric Company, Section H 668-89
Schenectady 5, N. Y.

Please send me the following bulletins:

- ☐ for reference purpose
- ☐ in connection with immediate projects

- ☐ GEA-4938-16 Motor selection and application
- ☐ GEA-5154 A-c magnetic contactors
- ☐ GEA-5174 Fractional-hp motors
- ☐ GEA-5334 Adjustable-speed manual
- ☐ GEC-254 Photoelectric recorder

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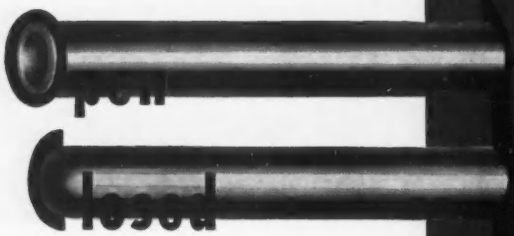
an open and closed case...



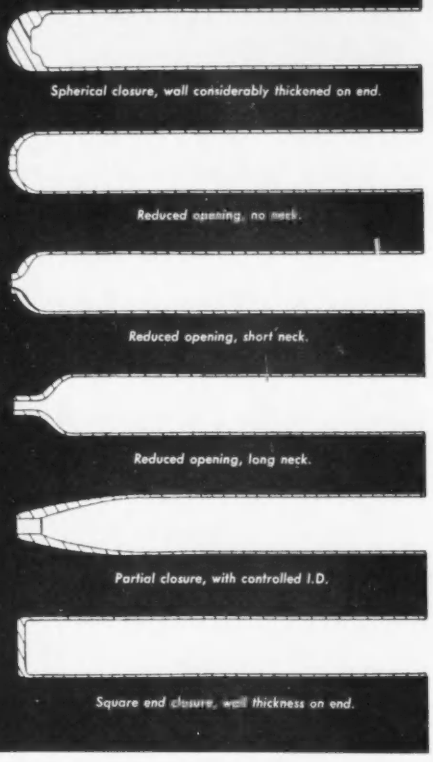
We employ this homely phrase because it suggests so well the idea of finality when applied to the Wolverine Spun End Process.* This process has solved so many problems, effecting economies and simplicity, that our reference as "an open and closed case" seems quite appropriate.

The process can be used most advantageously wherever the end of a tube is required to assume a rounded, tapered or related form—either completely or partially closed. Such end treatments often eliminate the use of additional parts and, of course, the attendant assemblies. They always tend to simplify the design and in most cases bring about worthwhile savings in material and labor.

Right now if you are contemplating production of tubular parts with special end treatments, consult our Customer Engineering Service. We are sure the help we can give you along this line will prove very valuable.

*a patented process RE. 22465

A FEW TYPICAL *End Forms*


Spherical closure, wall considerably thickened on end.
Reduced opening, no neck.
Reduced opening, short neck.
Reduced opening, long neck.
Partial closure, with controlled I.D.
Square end closure, wall thickness on end.

WOLVERINE TUBE DIVISION
Calumet & Hecla Consolidated Copper Company
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Manufacturers of seamless, non-ferrous tubing
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STRAIGHT LINE DRIVES

...for quality... economy... efficiency...

Line-O-Power Double Reduction

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QUALITY that starts with Duti-Rated, high hardness, precision helical gears, assembled into rugged cast housings of compact, streamlined design.

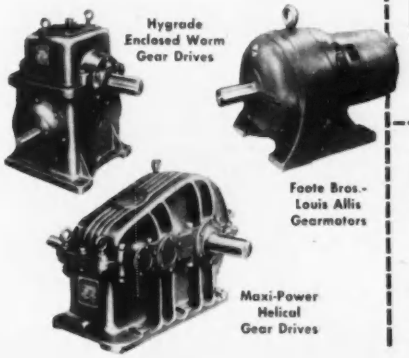
ECONOMICAL to buy because the latest, most accurate high production machine tools assure rapid production with exceptional accuracy for long wear life. Economical to operate because simplified construction, minimum number of moving parts, direct splash lubrication, quality workmanship—all hold maintenance to a minimum.

EFFICIENCY—Straight line design with Duti-Rated helical gears gives efficiencies of 96%, or higher.

Line-O-Power Drives are available in double or triple reductions for capacities from 1 to 200 h.p. with ratios from 5 to 1 up to 238 to 1.

FOOTE BROS. GEAR AND MACHINE CORPORATION
4545 S. Western Blvd. Chicago 9, Illinois

FOOTE BROS. manufactures a complete line of enclosed gear drives to meet any requirement.



Hygrade Enclosed Worm Gear Drives

Foote Bros.-Louis Allis Gearmotors

Maxi-Power Helical Gear Drives

FOOTE BROS.

Better Power Transmission Through Better Gears

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Chicago 9, Illinois

Please send me a copy of Bulletin LPB on Foote Bros. Line-O-Power Drives.

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THIS ADVERTISEMENT is part of the current campaign aimed at the 14 million readers of The SATURDAY EVENING POST.

BY USING PHILLIPS SCREWS on your product, you prove *on sight* that you use extra care in manufacture. The public knows that X marks the spot — the identifying X formed by the cross-recess on the head of every Phillips Screw. It is the mark of extra quality.

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Be sure to include Phillips Cross-Recessed-Head Screws in your specifications.

PHILLIPS *Cross-Recessed-Head* SCREWS

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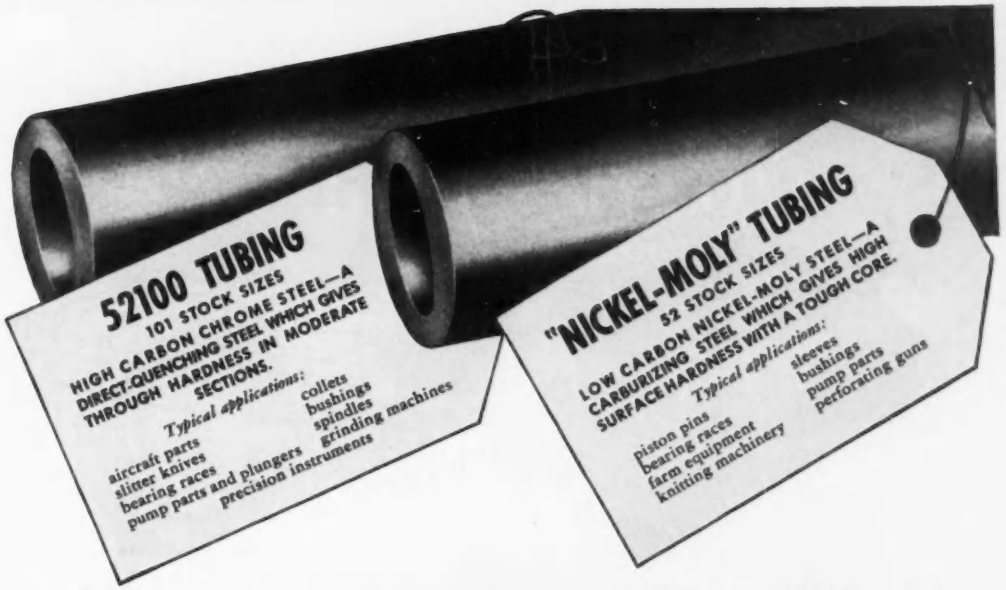


These two wear-resistant TIMKEN® steels will do 90% of your hollow parts jobs

WHEN you've a rush job on your hands, these two general purpose Timken® steels can be shipped to you in warehouse quantities within 24 hours after your order is received! With these two steels—52100 and "Nickel-Moly"—you can do 9 out of 10 of your hollow parts jobs. Both offer good hardenability and wear resistance.

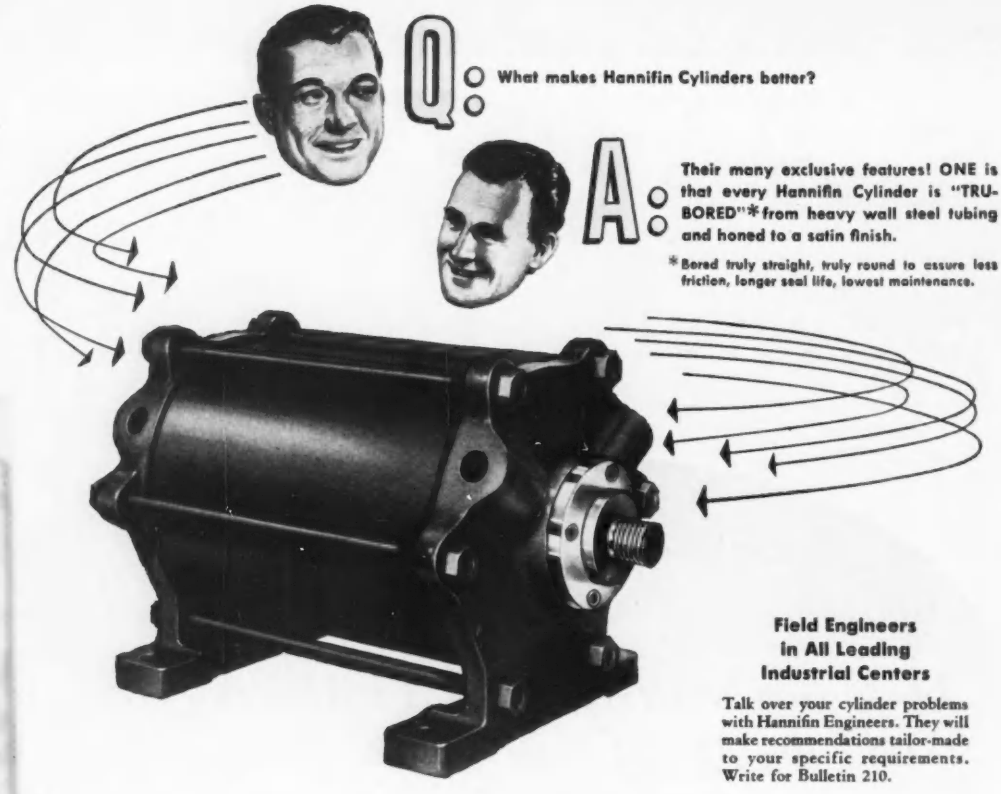
52100 steel, frequently substituted for costlier grades, can be heat treated to file hardness and tempered back to any desired point. In moderate sections it has through hardenability. "Nickel-Moly" is a fine-grained, carburizing steel that develops high case-hardness and a tough inner-core when heat treated, giving it exceptional stamina and shock-absorbing qualities.

52100 tubing is available from the Timken Company in 101 sizes, from 1" to 10½" O.D. And "Nickel-Moly" comes in 52 sizes, from 1⅜" to 10¼" O.D.

No matter which of these two Timken steels you order, you can be sure of uniform, high quality in every tube—and in every shipment. That's because every step of manufacture is rigidly and carefully controlled—from melting to final testing. Write for stock lists with the latest information on available sizes, grades and finishes. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing.



Q: What makes Hannifin Cylinders better?

A: Their many exclusive features! ONE is that every Hannifin Cylinder is "TRU-BORED"* from heavy wall steel tubing and honed to a satin finish.

*Bored truly straight, truly round to assure less friction, longer seal life, lowest maintenance.

Field Engineers in All Leading Industrial Centers

Talk over your cylinder problems with Hannifin Engineers. They will make recommendations tailor-made to your specific requirements. Write for Bulletin 210.

If you check on each operation in the manufacture of hydraulic and pneumatic cylinders, you will know why Hannifin precision methods are superior. Cylinder bodies are piloted into end caps for permanent concentricity of parts; complete standardization is maintained for maximum interchangeability; all cylinders are identified with individual serial numbers registered for life in factory records—it is this careful workmanship and attention to detail that assure maximum utility and minimum "down time" when you specify HANNIFIN CYLINDERS. Hannifin Corporation, 1125 S. Kilbourn Ave., Chicago 24, Ill.

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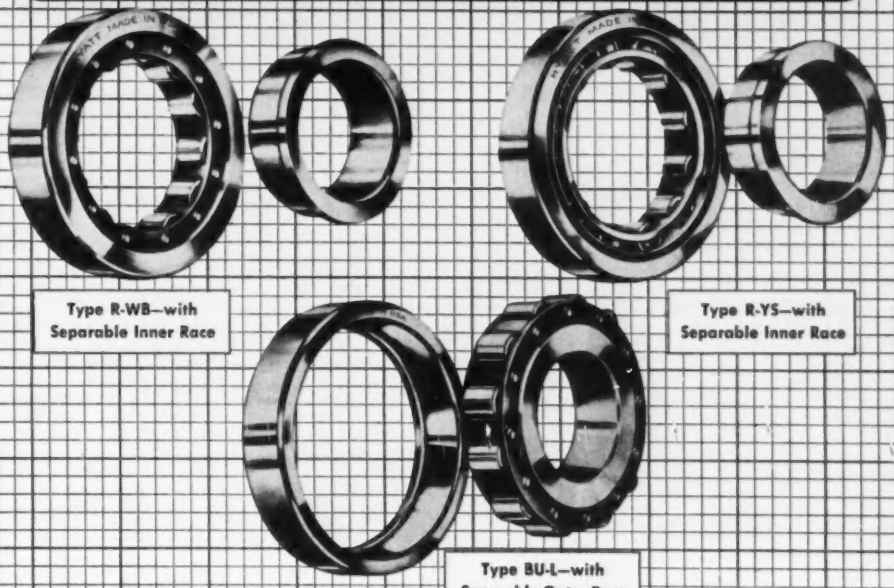
For Radial Bearings that can Locate Shafts HYATT HY-LOADS



Type R-WB—with Separable Inner Race

Type R-YS—with Separable Inner Race

Type BU-L—with Separable Outer Race

Designed for innumerable applications where the bearing load is primarily radial, Hyatt Hy-Load Roller Bearings can also provide for axial shaft location. When they are used in pairs they can locate the shaft in both directions.

The flanged race construction of the types of Hy-Load Bearings shown here makes this important advantage possible. Other advantages for the designer that are provided in the Hy-Load line are: option of omitted race operation, complete interchangeability of parts, maximum capacity for standard dimensions, ten different types in a wide range of sizes – along with long, trouble-free life.

Full information about Hyatt Hy-Load Roller Bearings is "yours for the asking" in Hyatt Catalog 547. Write today for a copy. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

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...Where *Carpenter* Customers Find New Ways to Get Stainless Jobs Done Faster

It's easy to see how *less tool grinding* means less machine down time. And it saves because you make fewer tools. *Reducing the number of rejects* on Stainless jobs—getting the best possible finishes—can make a big difference in your unit production rate, too.

Many a customer of ours has found this a good formula for easier machining of Stainless. First use the Stainless that is *uniform* every time you get it—*Carpenter* Free-Machining Stainless. Then take advantage of the shop help Carpenter can give you.

For example, the men who work out of your nearby Carpenter Mill-Branch Warehouse will be glad to help out on any problems that come up. Or, we can give you a personal copy of the Carpenter "NOTEBOOK on Machining Stainless Steels". It's packed full of useful shop hints on turning, drilling, threading, milling, lubrication, etc. If you would like a copy, just write us a note on your company letterhead, indicating your title.

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STAINLESS STEEL
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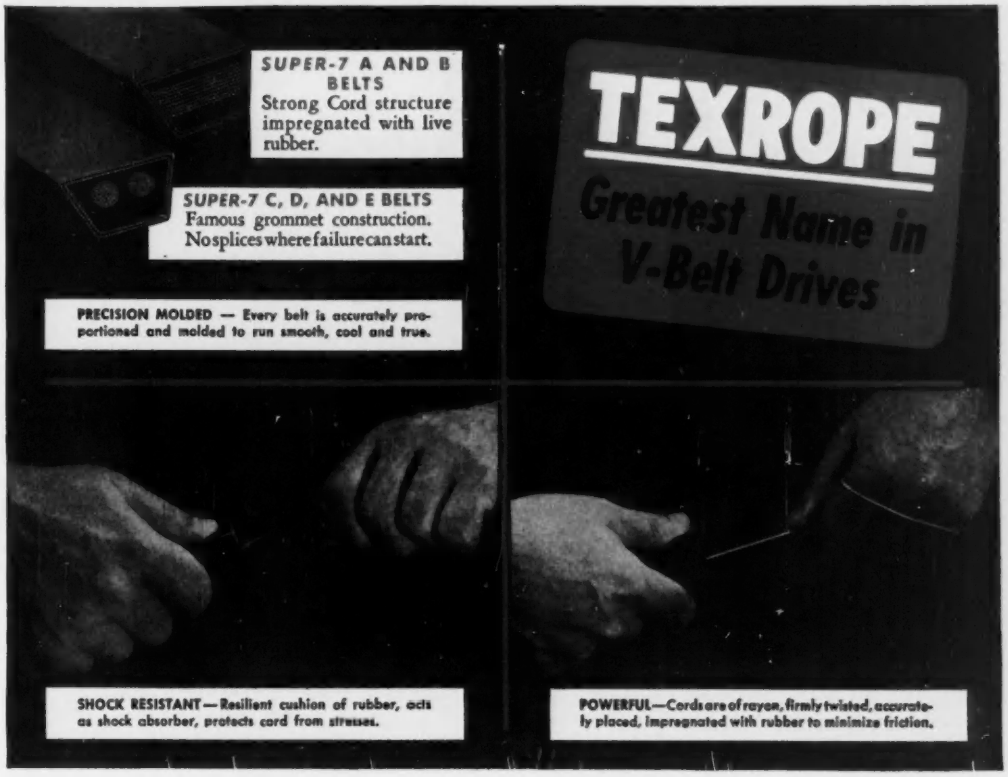
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Strong Cord structure impregnated with live rubber.
SUPER-7 C, D, AND E BELTS
Famous grommet construction. No splices where failure can start.
PRECISION MOLDED — Every belt is accurately proportioned and molded to run smooth, cool and true.
TEXROPE
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SHOCK RESISTANT — Resilient cushion of rubber, acts as shock absorber, protects cord from stresses.
POWERFUL — Cords are of rayon, firmly twisted, accurately placed, impregnated with rubber to minimize friction.

Cool Running...LONG LIVED!

SUPER-7 V-belts give long, satisfactory service even under bad conditions of load, shock and grit.

Tough, double-wrapped cover bias cut for elasticity and impregnated with rubber. Effectively seals out dust, grit, moisture; takes the wear; keeps the belt in shape; and protects cord structure.

But you get more than good belts when you standardize on *Super-7* V-belts. You also get the benefit of the greatest V-belt experience in the world both in the field and factory. You are assured of exactly the right drive for longest life from the wide variety of types and sizes available.

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Where space is limited or other special conditions demand heavier duty, the high capacity belt can be furnished in A, B, C, D, and E sections . . . Extra strong cords, special rubber cushion and tough Neoprene cover give them 40% greater capacity than standard belts at proportionately higher price.

V-Belt Drive Headquarters

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Wire Cloth

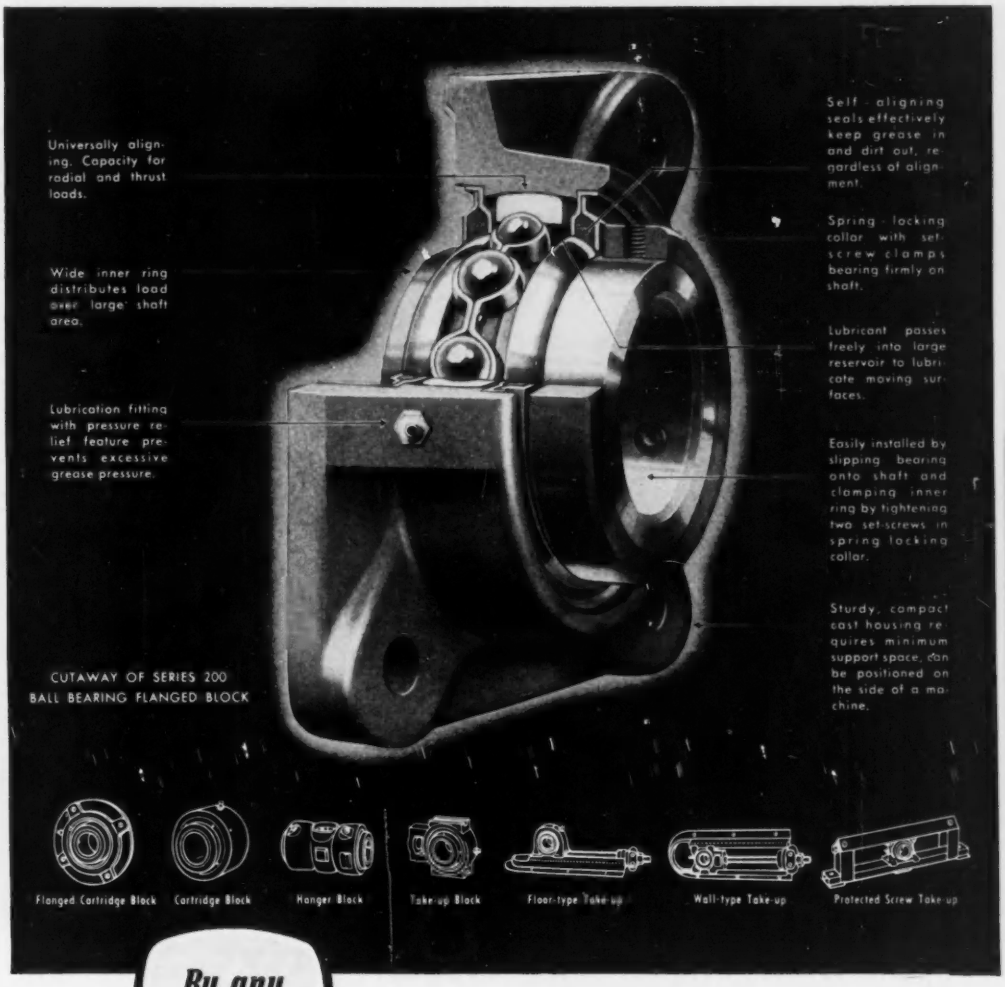
FOR ELECTRICAL APPLIANCES

The wire cloth used in television and radio sets is different than the wire cloth that the truck industry demands. The wire cloth in Diesels isn't identical with that in dishwashers. Metal, mesh, wire, weave—all vary. For your product—if you say "strictly to specification" Reynolds engineers and wire weavers can and will make wire cloth for you *exactly* that way. Because, after over fifty years of doing it, they *do* know how. But Reynolds engineering means *more* to you. It develops better wire cloth. That may help better your product.

REYNOLDS WIRE DIVISION
NATIONAL-STANDARD COMPANY
DIXON, ILLINOIS

NS NATIONAL-STANDARD Company

LINK-BELT Ball and Roller Bearings smooth the path of power


Universally aligning. Capacity for radial and thrust loads.
Wide inner ring distributes load over large shaft area.
Lubrication fitting with pressure relief feature prevents excessive grease pressure.
CUTAWAY OF SERIES 200 BALL BEARING FLANGED BLOCK
Self-aligning seals effectively keep grease in and dirt out, regardless of alignment.
Spring-locking collar with set-screw clamps bearing firmly on shaft.
Lubricant passes freely into large reservoir to lubricate moving surfaces.
Easily installed by slipping bearing onto shaft and clamping inner ring by tightening two set-screws in spring locking collar.
Sturdy, compact cast housing requires minimum support space, can be positioned on the side of a machine.
Flanged Cartridge Block
Cartridge Block
Hanger Block
Take-up Block
Floor-type Take-up
Wall-type Take-up
Protected Screw Take-up

By any standard . . .

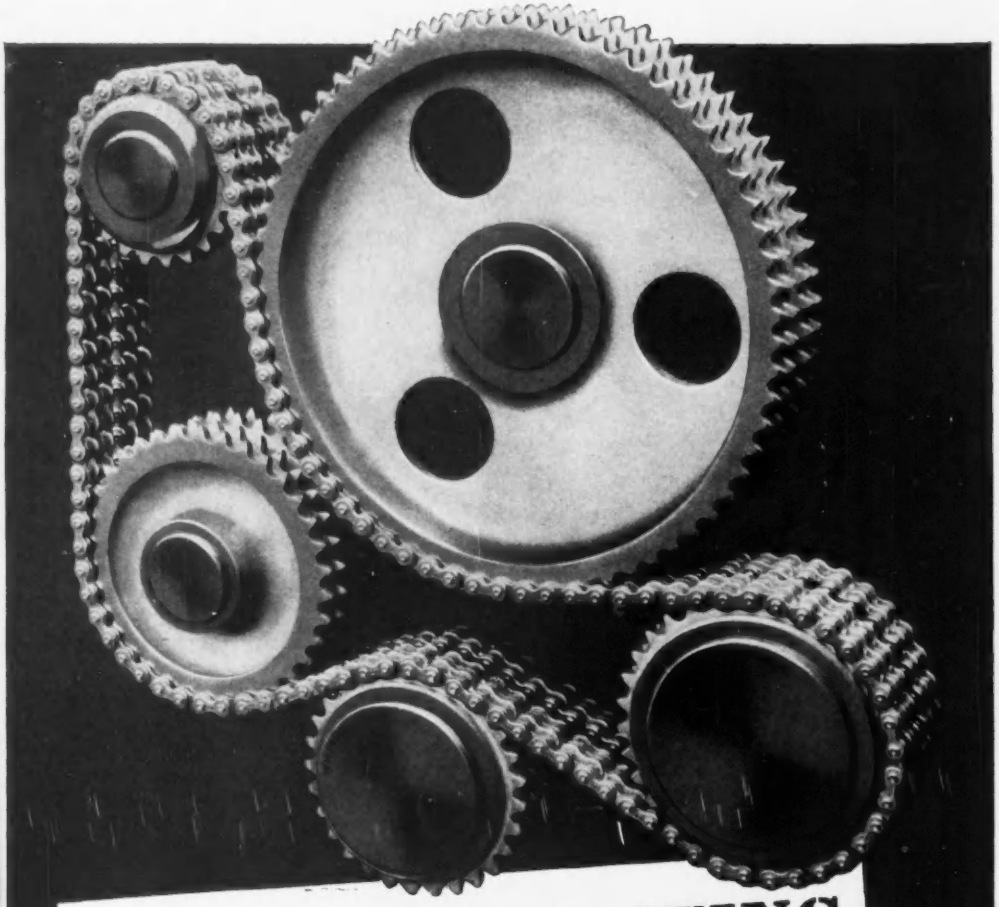
LINK-BELT builds a bearing block for every purpose

To meet any industrial requirement, Link-Belt builds ball and roller bearings in a complete line of mounting designs. All are made in a wide range of types and sizes . . . all are precision built for top efficiency and dependability. A Link-Belt bearing specialist will show you how the right bearing can be applied to match your exact needs. Or you can get engineering information from Data Book 2550.

LINK-BELT

Ball and Roller Bearings

LINK-BELT COMPANY: Indianapolis 6, Chicago 9, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Springs (South Africa). Offices, Factory Branch Stores and Distributors in principal cities. 1151



THE RIGHT SETTING
for a Whitney Chain Drive

Whitney Chain Drives Simplify Designs
Cut Costs of Complex Drive Mechanisms
Deliver Full Rated Horsepower

Shown above is a 5-point complex drive solved by Whitney roller chains. It clearly illustrates how the versatility of *Whitney Chain Drives will help you meet your design requirements* efficiently and economically.

Now take a look at the drive . . . see how the Whitney Chain is deeply seated in the sprocket teeth, assuring *positive grip*. Note that there can be *no slip* which means you get *full rated horsepower* from driver to driven mechanisms. This means machine output is maintained, highest transmission efficiency is always obtained . . . a vital factor in maintaining high production and product uniformity.

In addition, Whitney Chain Drives absorb shock loads without breakage. Their rugged construction assures long operating life with minimum maintenance. They save you time and money because they are easy to install, easy to remove without disconnecting shafts or bearings.

If your power transmission problems involve long or short centers, reversal of direction, timing motions, fractional or hundreds of horsepower, the unusual adaptability of Whitney Chain Drives will help you meet your design requirements efficiently and economically.

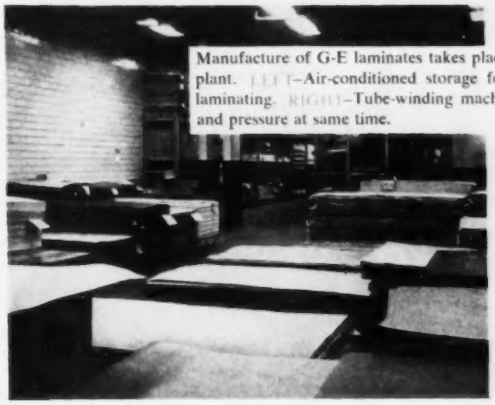
From the complete line of Roller, Silent and Conveyor Chain Drives, Whitney engineers can recommend, without bias, the proper type of drive for each application . . . the chain drive which will give you the best service at lowest cost.

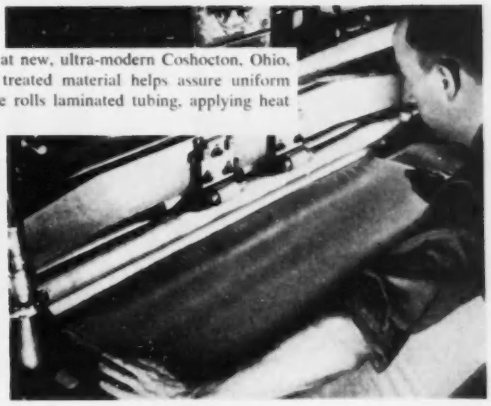
Consult your local Whitney Field Office or Distributor, or write direct to us for complete information and catalog.

Whitney Chain Company
204 HAMILTON STREET, HARTFORD 7, CONNECTICUT

LAMINATES NEWS

News of General Electric Laminated Plastics that can be of importance to your business.





Manufacture of G-E laminates takes place at new, ultra-modern Coshocton, Ohio, plant. LEFT—Air-conditioned storage for treated material helps assure uniform laminating. RIGHT—Tube-winding machine rolls laminated tubing, applying heat and pressure at same time.

EXCEPTIONAL CHEMICAL RESISTANCE IS FEATURE OF NEW G-E LAMINATE

Wherever corrosive chemicals are handled, it's worth considering equipment fabricated from a new phenolic (plastics) laminate recently announced by General Electric.

Designated G-E 2016, the new material is available in sheets and tubes. Important advantages for a wide range of industrial applications are *exceptional chemical resistance, mechanical toughness, resistance to repeated impacts.*

G-E 2016 is produced with canvas base material. Investigate its cost-saving possibilities in pipe lines, for fabricating plating tanks, dye vats, for structural work—where extra strength and chemical resistance are most important. *Write Section Y-4, Chemical Division, General Electric Company, Pittsfield, Massachusetts.*

G-E Laminates for Refrigerators

Laminated plastics for refrigerator inner-doors are preformed by G.E. and supplied to many major manufacturers. Advantages of this use of G-E laminates over metal materials mean better insulation, less condensation, improved finish, rustlessness, reduced weight, elimination of denting. *Look into G-E molded laminates for your products!*

Complete Line of G-E Laminates

General Electric produces a complete line of laminated plastics—either molded or in forms of sheets, tubes and rods, with cloth, paper, glass fabric or special bases—for a wide variety of applications. *(Also, look to General Electric for silicone insulation, insulating varnishes, sealing and filling compounds, mica insulation, varnished cloth and tape.)*

DEFENSE CONTRACTORS!

Investigate the many ways G-E Laminated Plastics do the work of metals—and do it better—as parts, structural materials, electrical insulation. General Electric is ready to work with you in every stage of product development.

You can put your confidence in

GENERAL ELECTRIC

Positive snap action . . . for military and civilian applications

Klixon Thermo-Snap Controls . . . hermetically sealed and open types . . . give accurate temperature control. Actuated by the simple, snap-acting "Spencer Disc," their snap-action opens the circuit with a *quick, clean break* . . . closes the circuit to a *solid make*. Their accurate operation is best able to withstand shock, vibration, altitude or motion.

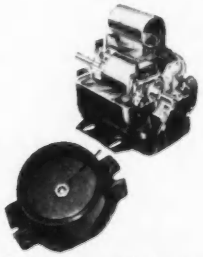
Klixon Thermo-Snap Controls are used in many military and commercial applications including use as — low limit and high limit controls, fuel delay switches, purge switches, temperature controls, fan switches, tube and rectifier cooling control, etc. . . . in products ranging from tanks and airplanes, sterilizers, radio and electronic equipment to household electric appliances, dairy heaters, etc.

They are available in many types and ratings including completely hermetically sealed units. Our engineers will gladly help you with your problems. Write for information today.

KLIXON

SPENCER THERMOSTAT
Division of Metals & Controls Corp.
907 FOREST ST., ATTLEBORO, MASS.

KLIXON
MOTOR PROTECTORS
PREVENT MOTOR BURNOUTS



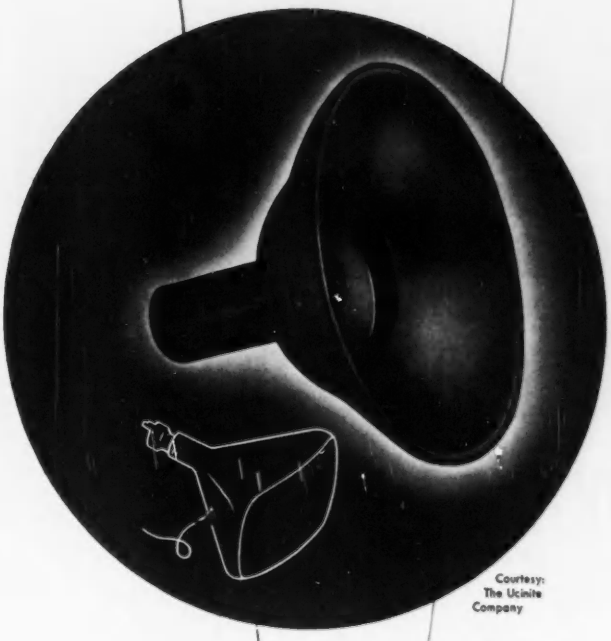
To keep motors operating longer specify and use motors with built-in Klixon Protectors. Should a motor become overheated, the Klixon Protector snaps the power "off," preventing a motor burnout. When it cools to safety, the protector snaps the power "on" automatically if the *automatic reset* is specified . . . or by pushing the *red button* when the *manual reset* type is used.

HEAT RESISTANCE

OZONE RESISTANCE

These properties of neoprene make a better

TELEVISION ANODE SHIELD



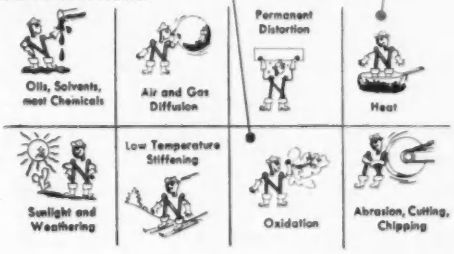
Courtesy: The Ucinite Company

Picture distortion resulting from surface discharge is eliminated by this neoprene shield. Located on one side of the tube, the anode shield "seals in" high voltage current. And Du Pont neoprene's unusual properties make it particularly suited for the job.

Engineers specified neoprene for this vital part because it resists the effects of ozone created by high voltage current. And neoprene filled another need with its remarkable stability under sustained heat. What's more, neoprene's long lasting resiliency permits the shield to fit perfectly over the anode—tight against the tube.

Neoprene's outstanding characteristics play an important part in the success of this and many other critical rubber products. Rubber goods manufacturers can compound neoprene to meet many exacting requirements.

PROPERLY COMPOUNDED NEOPRENE WILL RESIST:



DU PONT

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

NEOPRENE

The rubber made by Du Pont since 1932

FREE! **THE NEOPRENE NOTEBOOK**

Full of interesting stories. New, unusual applications of neoprene to build new products . . . improve old products . . . reduce maintenance costs.

E. I. du Pont de Nemours & Co. (Inc.)
Rubber Chemicals Div. B-7, Wilmington 98, Del.
Please send me free issues of **The Neoprene Notebook.**

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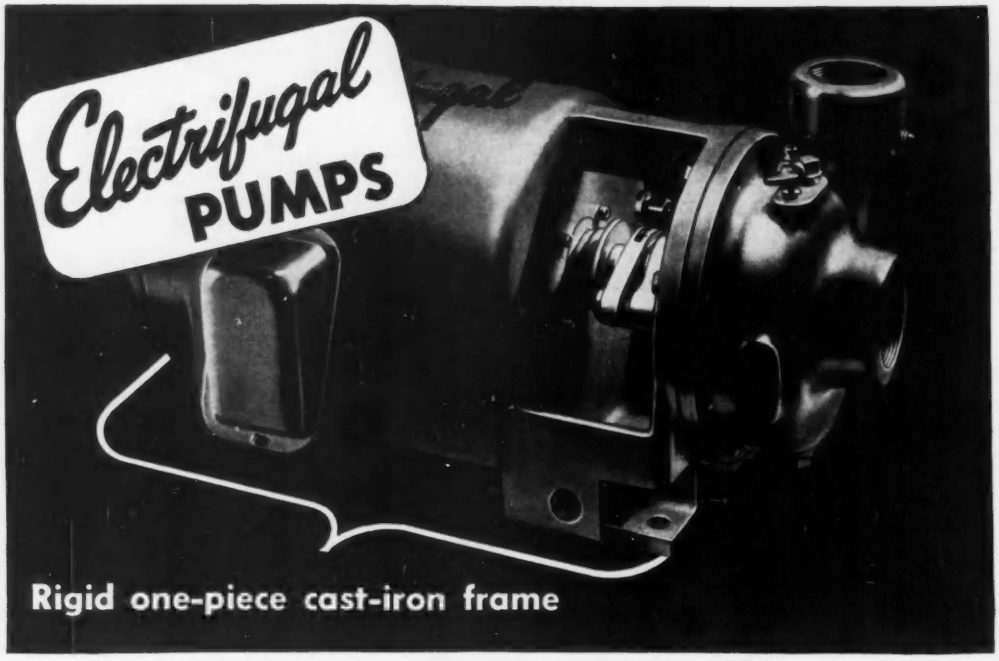


This is the difference between close-coupled pumps

THIS EXCLUSIVE FRAME DESIGN combines maximum space for packing maintenance with exceptional rigidity in a way that no pump assembled to a standard motor can do. Solid cast iron with no joints from motor end housing to pump casing assures permanent alignment.

Bearings are lubricated at the factory and should require no attention for years. The stuffing box carries plenty of packing and all parts are generously proportioned for heavy duty service. As a result, your customers will find exceptional freedom from high maintenance costs.

Keep Your Costs Down, Too

You will like the *Electrifugal* pump because it makes your work easier and keeps your costs down. You can specify pump and motor as one unit without having to figure a drive. Every Allis-Chalmers pump representative is a competent application engineer who will help you select exactly the right pump for your needs. Motor and pump are designed for each other and made in the same plant. You have one responsible source of supply for both . . . one guarantee of satisfaction. And 94 Allis-Chalmers Certified Service Shops provide nation-wide factory approved service.

Talk over your pump selection problems with your nearest Allis-Chalmers Authorized Dealer or Sales Office, or write Allis-Chalmers, Milwaukee 1, Wisconsin and ask for Bulletins 52B6059 and 52B6140.

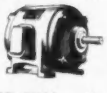
A-3324

Electrifugal, Texrope and Vari-Pitch are Allis-Chalmers trademarks.

ALLIS-CHALMERS

Sold . . .
Applied . . .
Serviced . . .

by Allis-Chalmers Authorized Dealers, Certified Service Shops and Sales Offices throughout the country.

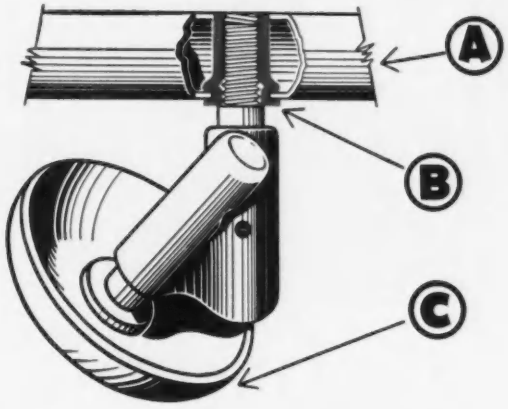


MOTORS — ½ to 25,000 hp and up. All types.

CONTROL — Manual, magnetic and combination starters; push button stations and components for complete control systems.

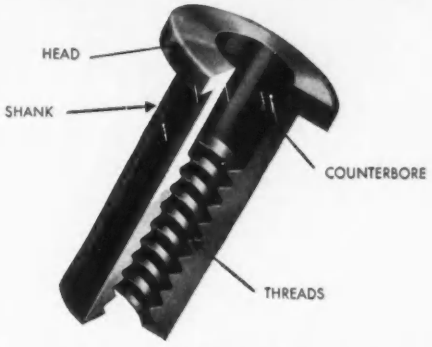
TEXROPE — Belts in all sizes and sections, standard and *Vari-Pitch* sheaves, speed changers.

RIVNUT provides six threads in tubing to fasten caster



DESIGNERS of the "Glide-Or-Seat" creeper had the tough problem of fastening casters Ⓒ to the steel tubing frame Ⓐ. Tapping gave only 2½ threads. Welding warped the tubing. Rivnuts—the *only* one-piece blind rivet with threads—proved the answer! Installed from one side, *after* painting, in a few seconds, the Rivnut Ⓑ provides at least 6 clean threads to take the caster attachment screw. Product quality was improved. Assembly costs were cut. Got a fastening problem? Call in a B. F. Goodrich Rivnut engineer! The B. F. Goodrich Company, Dept. PE-71, Akron, Ohio.

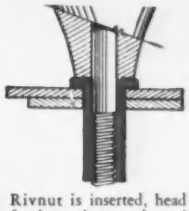
THIS IS A B. F. GOODRICH RIVNUT . . . . THIS IS HOW IT WORKS



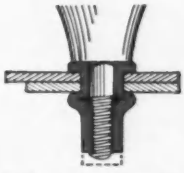
This cross-section shows the threads by which the Rivnut is threaded onto the pull-up stud of the heading tool. These threads are not injured by the heading operation and enable you to fasten *to* a Rivnut as well as *with* it.

The Rivnut provides a large bearing surface, requires only a small hole, and can be installed after enameling without marring the finish.

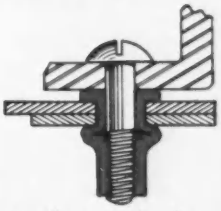
1. Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.



2. Rivnut is inserted, head firmly against work, tool at right angles to work.



3. Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.



4. After upset, threads are still clean and intact, ready for screw attachment.

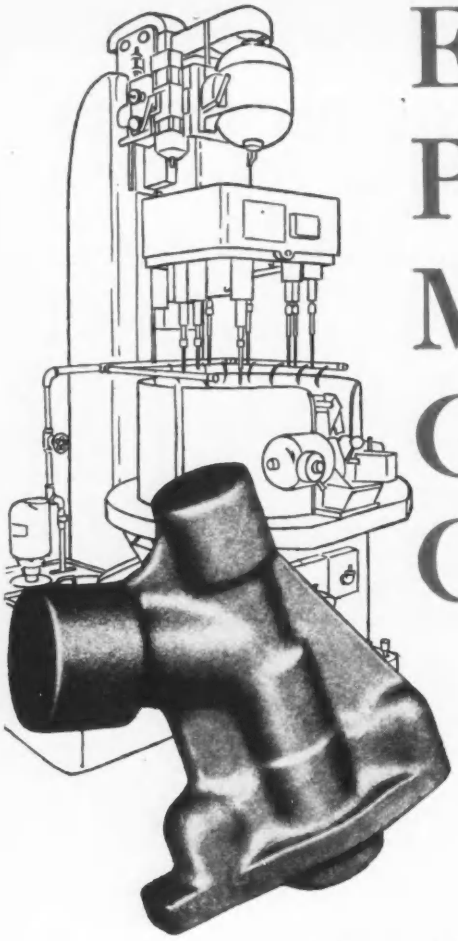
B.F.Goodrich

RIVNUTS

The only one-piece blind rivet with threads

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Shows with motion how Rivnut works. Explains construction, gives applications. Write to: B. F. Goodrich, Dept. PE-71, Akron, O.



Eaton Permanent Mold Gray Iron Castings

for
HIGH PRESSURE CONTROL MECHANISMS

- **Free machinability**
- **Dense, homogeneous structure**
- **Freedom from leakage under pressure**
- **Machines to high, mirror-like finish**
- **Properly annealed; no growth or distortion after machining**

Send for your copy of the illustrated booklet, "A Quick Picture of the Eaton Permanent Mold Process for Producing Gray Iron Castings."

EATON MANUFACTURING COMPANY

CLEVELAND, OHIO

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PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

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Sealing around rotating shaft having angular movement

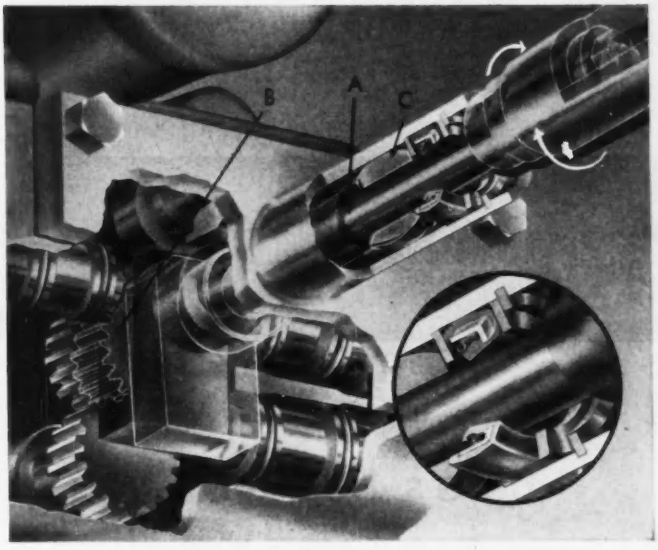

Figure 1
Cut-away of portion of Gemmer HYDRAGUIDE showing location of Syntech oil seal and angular movement of steering shaft.

Rotating shafts using spherical bearings to permit a planned angular movement or self-alignment, require special performance capabilities in the oil seals. A striking example is found in HYDRAGUIDE, the new Gemmer power steering gear, where the steering shaft makes an angular movement of as much as 38° each side of center to actuate the hydraulic valves in the mechanism.

In the cut-away drawing (Fig. 1) the shaft (A) is connected through a rubber universal to the steering post. As the steering wheel is turned, the spur gear (B) tends to rotate around the mating gear. This results in an angular movement of the shaft permitted by the spherical bearing located at (C) in the drawing. Adjacent to this bearing, a National Syntech† stock design 350,000 series, rubber-covered, spring-tensioned oil seal (Fig. 2) is employed.* This seal is sufficiently flexible to follow the lateral movement of the shaft and still provide dependable protection for the bearing and other internal mechanical parts.

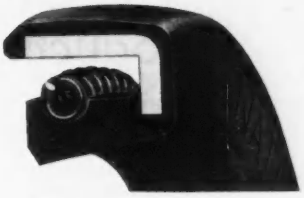

Figure 2
Modified National 350,000 series Syntech oil seal as used in the Gemmer HYDRAGUIDE.

Gemmer's adoption of this stock design National Seal is a tribute to the inherent performance capabilities which it possesses. The sealing lip, with carefully designed flex section, is well known for its ability to provide zero leakage performance under certain conditions of shaft-whip, run-out misalignment and pressure. The rubber covering on the O.D. of the seal provides a perfect seal at the outer periphery.

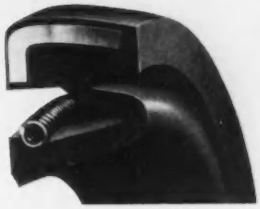

Figure 3
National Convoluted Flex type Syntech seal.

Where shaft eccentricities are extreme, special oil seals are available. Typical example is the National Convoluted Flex type seal (Fig. 3) employing extra spring-tensioning and an extra long lip design which can follow shaft displacements of as much as ⅛ inch.

National Oil Seal engineers have had experience with a wide variety of sealing problems. This experience is yours for the asking. Perhaps you have a sealing problem that can be solved with one of our stock designs, or perhaps a new design is required. In either case, we will be glad to help you.

"Let Your Decision be Based on Precision"

NATIONAL
OIL AND FLUID SEALS

NATIONAL MOTOR BEARING CO., INC.
General Offices: Redwood City, California
Plants: Redwood City, Calif.; Downey (Los Angeles County), Calif.; Van Wert Ohio

2276

**Elsewhere in this mechanism three other stock design National 240,000 series Syntech springless type oil seals are employed as well as a total of 25 "O" Rings which are utilized in the hydraulic pistons and as gaskets.*

†Trade mark registered.

CALL IN A NATIONAL ENGINEER FOR RECOMMENDATIONS

BUFFALO, N. Y. . . . *Room 1124, Prudential Bldg., Mohawk 9222*
CHICAGO, ILL. . . . . *Room 2014 Field Building, Central 6-8663*
CLEVELAND, OHIO . *210 Heights Rockefeller Bldg., Yellowstone 2-2720*
DALLAS, TEXAS . . . *30½ Highland Park Village, Justin 8-8453*
DETROIT, MICH. . . . . *726 Lothrop Avenue, Trinity 1-6363*
DOWNEY (Los Angeles Co.), CALIF. . *11634 Patten Rd., Topax 2-8166*
MILWAUKEE, WIS. . . *647 West Virginia Street, Broadway 1-3234*
NEW YORK CITY, N. Y. . . *122 East 42nd Street, Lexington 2-8260*
PHILADELPHIA, PA. . . *401 North Broad Street, Bell-Walnut 2-6997*
REDWOOD CITY, CALIF. . . *Broadway and National, Emerson 6-3861*
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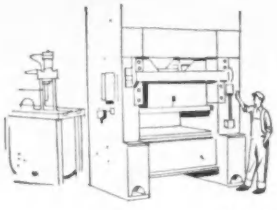
SYRACUSE, N. Y. . . . . *P.O. Box 1224, Baldwinsville 662*
WICHITA, KANSAS . . . . *519 South Broadway, Wichita 2-6971*

let's look at the shape of things to come!

. . . if future plans require it . . .



here's how **you** can cut costs with fewer production operations

You can cut many production steps with plastics today . . . and particularly with the plastic that leads the parade . . . *polystyrene!*

Rapid advances in polystyrene research, in molding techniques and machinery allow you to produce *larger area moldings* in one piece . . . many with complicated and intricate design features. With these new moldings, you may be able to increase your production cycle.

Also—light-weight polystyrene comes in a wide range of built-in colors . . . colors that won't chip, peel or rust. This means that you can keep your finishing operations to a profitable minimum.

Dow, as a leader in the plastics industry, offers you a complete line of *quality controlled* polystyrene plastics under the registered trade mark, Styron, plus the expert assistance of Dow's Plastics Technical Service. When looking at the shape of things to come in '51, be sure to include Styron in planning for future civilian or defense products. Write Dow today.

Plastics Division—Dept. PL-73

THE DOW CHEMICAL COMPANY

MIDLAND, MICHIGAN

New York • Boston • Philadelphia • Washington
Atlanta • Cleveland • Detroit • Chicago • St. Louis
Houston • Los Angeles • San Francisco • Seattle
Dow Chemical of Canada, Limited, Toronto, Canada

STYRON

. . . a quality plastic for a quality job!

DOW plastics

OVERLOAD PROTECTION

FOR SMALL MOTORS

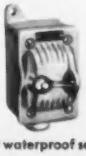
COMPLY WITH THE NATIONAL ELECTRICAL CODE

by using the Approved Bulletin 600 Starting Switch

Toggle lever switch with cover removed

Key operated for public places

For hazardous gases



For waterproof service

It looks like an ordinary snap switch . . . but something has been added . . . a self-contained thermal overload breaker. The heater element quickly detects an overload on the motor. It releases a soldered ratchet . . . the contacts snap open, automatically.

The motor is thereby disconnected before a burnout can occur . . . and it cannot restart until the toggle lever is flipped down manually to reset the overload breaker. If the overload persists, the contacts cannot be held closed by the operator.

This compact starter, rated at 1 hp, 110-220 v, is a favorite with engineers who want a small, inexpensive switch to protect fractional horsepower motors. Send for Bulletin 600.

Allen-Bradley Co.
1316 S. Second St., Milwaukee 4, Wisconsin

5-51-MR

A-B Quality

ALLEN-BRADLEY

BULLETIN 600 STARTING SWITCHES

QUALITY

BIG NEWS

ABOUT A SMALL SWITCH
that provides
OVERLOAD PROTECTION
for motors up to
1 hp, 110-220 v, a-c
and
¾ hp, 110-220 v, d-c

Here is an 8-page illustrated bulletin, filled with engineering data on the various types and forms of Bulletin 600 starters now available to you.

Below are a few of the many convenient standard enclosures for different service requirements.

This handy reference booklet is a quick guide for busy engineers. May we send you a copy?

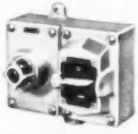
Allen-Bradley Co.
1316 S. Second St., Milwaukee 4, Wisconsin

BULLETIN 600 MANUAL STARTING SWITCH for SMALL MOTORS

Two starters in one enclosure

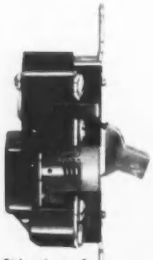
Starter with selector switch

Starter with pilot light


Watertight starter with pilot light

In standard wall box

AVAILABLE IN ENCLOSURES FOR EVERY APPLICATION

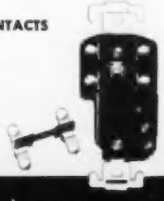

Side view of starter, showing heater element coiled around the stud.

THERMAL OVERLOAD BREAKER

Soldered ratchet of overload breaker is mounted on a heater stud. Around the stud is the coiled thermal element which heats the stud. Overload melts the solder; ratchet is released. This automatically opens switch with snap action.

DOUBLE BREAK SILVER ALLOY CONTACTS

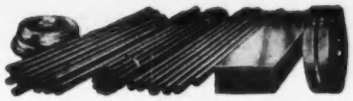
Switch contacts are quick make, quick break. In the 2 pole construction, each side of line has two stationary contacts bridged by the double moving contacts. They need no contact maintenance, because they form no insulating oxides.



5-51-R

A-B Quality

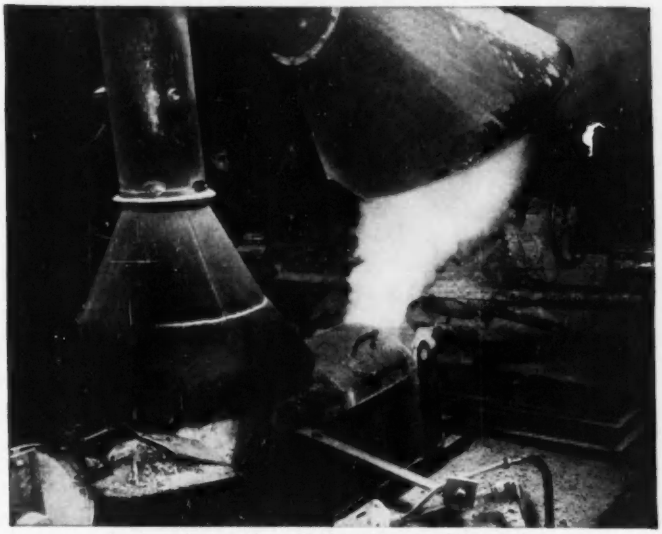
ALLEN-BRADLEY
BULLETIN 600 STARTING SWITCHES
QUALITY



BRIDGEPORT BRASS COMPANY

COPPER ALLOY BULLETIN

"Bridgeport" BRASS CO. MILLS IN BRIDGEPORT, CONN. AND INDIANAPOLIS, IND.—IN CANADA: NORANDA COPPER AND BRASS LIMITED, MONTREAL



Continuous Casting of Brass at Bridgeport Brass Co., Bridgeport, Conn.

Brass Scrap Situation and Its Effect on Brass Production

Copper and zinc, essential metals for both military and civilian needs, have been in short supply for many months and the situation has been growing worse. After taking care of the mounting volume of DO orders, there is not enough remaining to take care of civilian needs even at the reduced allotment.

As far as we can learn, there has not been a sufficient increase in the production of copper and zinc to satisfy this unprecedented demand and to take care of the requirement of the government stock piling, defense and foreign rearmament programs.

The high volume of production of brass mill products during 1950 and the early part of 1951, has been possible only because the mills have dipped into their metal inventories which are at their lowest ebb today.

From the brass mill standpoint, the short supply of zinc has been critical because it is needed for alloying with copper to produce brass. Zinc acts as a means of stretching the available supply of copper because when alloyed with 100 pounds of copper it can result in about 145 pounds of brass. This increased tonnage will serve a larger number of users.

However, to augment the supply of zinc and copper, the brass mills use clean brass scrap, viz., clippings, rod ends, and shavings generated during metal goods fabrication. The scrap is added to the melt with new metal and is eventually turned into new mill products.

It has always been the custom for the brass mills to buy back the brass scrap from their mill products, customers and metal dealers at definite published prices which reflect the prevailing prices of new copper and new zinc.

Today, because of the voracious demand for brass scrap, its price has been raised considerably beyond that of virgin metal. As a result, a portion of this scrap, which would ordinarily be returned to the brass mills, has been diverted to other channels.

The serious shortage of copper and zinc, plus the insufficient brass scraps being returned to the mills explains in part why the brass mills are operating on a reduced schedule and are not able to fill the many orders which have piled up.

Some Scrap Diverted

The scrap situation can be improved if metal goods manufacturers will make sure that *all* their scrap is returned to the brass mills. Although most manufacturers make it a practice to do so, there are some smaller ones who think that their scrap generation is insufficient to count. However, when the scrap generation of all small manufacturers are added up, the total becomes worthwhile.

It is true that in some cases brass scrap can fetch higher prices than that offered by the brass mills. Unfortunately, if this scrap does not find its way back to the brass mills, the brass mill tonnage is reduced and all brass users suffer.

How Brass Users Can Help

Here are a few suggestions which, if followed by metal goods manufacturers, would help the scrap situation considerably.

1. Store all scrap in clean containers, keeping it separated by alloy and properly identified.
2. When a sufficient quantity has been collected, notify the brass mill for whom it is intended. Give details as to weight, alloy, character of scrap. Ask the brass mill to collect it either in their own trucks or to designate the particular scrap dealer which does this work for the brass mill.
3. If you know where there are clippings of zinc resulting from manufacturers' cups or stampings, or scrap copper wire or other forms of good clean scrap of brass, bronze or copper not generated by brass goods manufacturers, please notify your supplier of brass mill products. (6867)

Springs that stay Springy ...up to 750° F.

This view shows how the tube is placed on the spider which is held in place by an Inconel "X" spring. Designed for Federal Telephone and Radio Corp., Clifton, N. J.

Inconel "X" springs retain properties in high-temperature ovens

High temperatures take the life out of most springs . . .

Trutner and Boumans, Inc., Hillside, N. J., had just such a problem.

They had designed a new type of television tube screen baker for driving off moisture and volatiles on the fluorescent screens. The baker carried the tubes through a gas-heated circular oven which gradually reached a temperature of 750°F.

Their problem was to find a spring material that would stand the high temperatures and exert just the right pressure (3 to 4 pounds) to hold the spider guide fitting in the neck of the tube.

They brought their problem to INCO...

INCO spring specialists studied the design specifications and then recommended .042" Inconel "X" wire.

Inconel "X" is one of the new superalloys developed for use in jet planes and other high temperature applications . . . a heat resisting alloy of nickel and chromium that can be age-hardened to get high hot-strength and hardness.

The oven has now been operating round-the-clock, 24 hours a day for over ten months. And there has not been a single spring failure.

Like Trutner and Boumans, many other manufacturers have found that both high- and low-heat problems can be solved dependably with the versatile INCO Nickel Alloys. Each of these individualized metals offers special advantages in addition to remarkable resistance to corrosion and destructive oxidation.

Right now you may find the INCO Nickel Alloy you need is hard to get. That's because so much of INCO's production is being diverted to defense. But, if you have a special metal problem, INCO's engineers will be glad to study it and make suggestions.

MONEL® • "R"® MONEL • "K"® MONEL "KR"® MONEL • "S"® MONEL • NICKEL LOW CARBON NICKEL • DURANICKEL® INCONEL® • INCONEL "X"®

INCO TRADE MARK

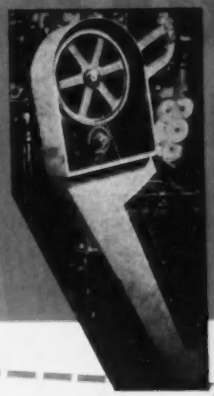
THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street, New York 5, N. Y.

BY "SAVING" $19.90 ON THESE TWO DRIVES THEIR USERS LOST $446.10

This compact, efficient, long lived polishing machine drive comprises BOSTON RATIOMOTOR, BOSTON SPROCKETS and CHAIN, BOSTON GEARS.

This textile yarn drawing machine drive employs BOSTON SPROCKETS, BOSTON DOUBLE ROLLER CHAIN, BOSTON GEARS. Oil tight chain case permits oil-bath lubrication. Maximum production, no slippage, no power loss, minimum maintenance are assured by this drive.



To save **$12.50** first cost this chain drive on a sheet metal polishing machine was equipped with cheap sprockets. They wore out fast — caused a wobble that hurt machine performance — had to be replaced by BOSTON Sprockets and Chain.

Cost of replacing drive (two men, 4 hrs. @ **$4.25** per hr.) — $34.00.

Down time loss (profit and overhead) 4 hrs., 30 sheets per hr., **$1.20** per sheet — $144.00.

$144 + 34 — 12.50 = $165.50 *net loss.*

To save **$7.40** this textile machine drive was equipped with "bargain counter" sprockets and chain. It wore out and broke down *twice*, before being replaced by BOSTON Sprockets and Chain.

Cost of replacing drive, *two times* (two men, 4 hrs. each @ **$3.00** per hr., each time) — $48.00.

Down time loss (profit and overhead) 80 bobbins, 4 hrs. down, each time, **$1.50** per bobbin — **$120.00** x 2 — $240.

$240 + 48 — 7.40 = $280.60 *net loss.*

It pays to buy the best — Boston Gear Sprockets. Design them into your equipment. Always specify them for replacements.

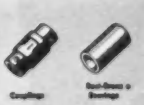
BOSTON *your* stocks are *Here*

(See adjacent list of Authorized Boston Gear Distributors)

Write for Catalog No. 55. It contains a wealth of useful data and selection charts.

BOSTON GEAR WORKS

71 HAYWARD ST., QUINCY 71, MASS.



BOSTON *your* stocks are *Here*

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CLEVELAND, OHIO
COLUMBUS, OHIO
DALLAS, TEXAS
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NEWARK, NEW JERSEY
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PHILADELPHIA, PENNSYLVANIA
PITTSBURGH, PENNSYLVANIA
PORTLAND, OREGON
PROVIDENCE, RHODE ISLAND
QUEBEC, QUEBEC
QUINCY, MASSACHUSETTS
RICHMOND, VIRGINIA
ROCHESTER, NEW YORK
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WINSTON-SALEM, NORTH CAROLINA
WORCESTER, MASSACHUSETTS

Sure Stainless Pipe

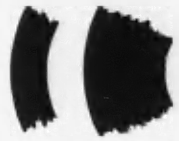
is Tough to Get...

but using light weight *Schedule 5 Pipe* will almost double the supply

—and you pay less per foot!

What Schedule 5 Pipe Is—

A light wall pipe, Carpenter *Schedule 5* gives you more feet of pipe for every pound of scarce stainless steel. So you can quickly see how *Schedule 5* increases the amount of pipe available and reduces your cost per foot. Plus the fact that the larger I.D. means increased flow area. These cutaway sections of pipe show the actual difference in wall thickness.



Schedule 5 Schedule 40
2" I.P.S. (4x)

How Schedule 5 Reduces Costs

First saving is 40% to 50% on the cost of your pipe. And, because *Schedule 5* lets you use the next smaller pipe size, you reduce by as much as 25% your costs of valves, fittings, etc. Carpenter *Schedule 5* Pipe often permits the use of the next smaller pipe size, because of its larger inside diameter.

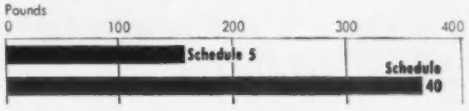
How It Hooks Up With Tube

This pipe is easily adapted to use with existing lines of tubing or Schedule 40 and 10 pipe, using simple connectors available from several manufacturers.

Why It Means More Pipe

You get *more feet of pipe* for every pound of material with Carpenter *Schedule 5* Stainless Pipe. And we don't have to tell you how important it is to get *more steel* from every pound of nickel and chrome these days.

2" I.P.S. STAINLESS PIPE weight per 100 feet



How It Resists Corrosion

You get the full corrosion resistance of the stainless analysis with Carpenter *Schedule 5* Pipe. It is made in standard A.I.S.I. analyses of stainless steel.

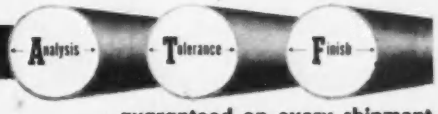
What Pressures It Handles

All sizes of Carpenter *Schedule 5* Pipe will handle 150 psi working pressures with a good margin of safety. Sizes up to 1½" will safely handle considerably higher working pressures. Where high pressures are involved, however, Schedule 40 may be required.

Data Sheets Give You More information about this opportunity to get more stainless pipe for essential uses. Write for a copy now. Under today's conditions, Carpenter *Schedule 5* Stainless Pipe may help solve several big problems, including "When can I get the pipe I need?"

THE CARPENTER STEEL COMPANY
Alloy Tube Division, Union, N. J.
Export Department: Carpenter Steel Co., Reading, Pa., "CARSTEELCO"

Carpenter
STAINLESS TUBING & PIPE



- guaranteed on every shipment

purchasing agents know...

there's no guess when it's a finish by...

STANDARD

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Superior on-the-job performance and quality have linked Industrial Finishes by STANDARD to industry since 1870.

Purchasing agents who have no time for guesswork and speculation as to which industrial finish is best for their purposes, consistently choose Industrial Finishes by STANDARD.

This is because these men realize the greater demands of hard wear and industrial abuse. They know they must have finishes that give superior performance, that stand up better under punishing conditions, and that still retain their luster and attractiveness. For many years, Industrial Finishes by STANDARD have continually met the test and have proven to be uniform in performance. It is easy to see, then, why purchasing agents have continued to put their confidence in STANDARD.

Finishes to meet U. S. Government specifications.

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Makers of Fine Finishes Since 1870

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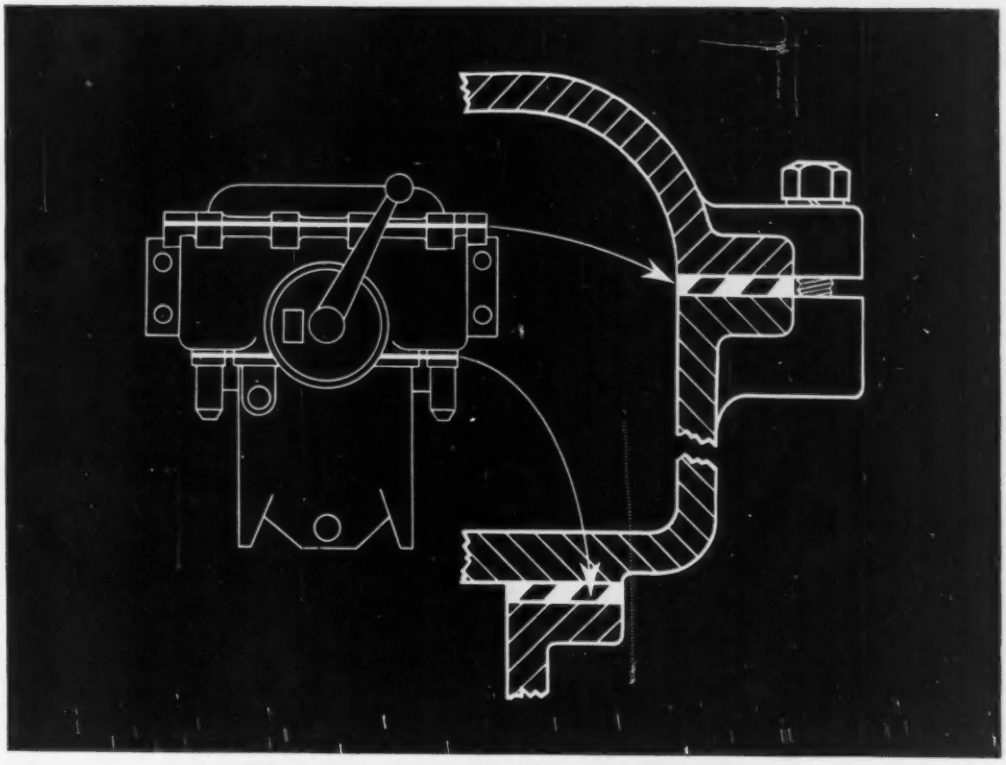

Check these three factors to insure correct gasket compression

Three common factors may upset expected gasket compression. They are (1) condition of the flange surface, (2) gasket width, and (3) gasket thickness. If gasket choice does not take these factors into account, gasket failure may result.

On clean flanges, for example, the surface friction of straight rubber normally impedes sideflow. If this friction is cut by wet gasket cement or grease, it will upset load estimates based on laboratory tests on dry rubber between non-skid plates. Even a virtually invisible oily film may cause a rubber gasket to sideflow excessively or slip out of position.

This trouble was encountered on the oil-filled circuit breaker shown above. During assembly and maintenance, the straight rubber gasket squeezed out. Substituting a cork-and-rubber gasket eliminated this excessive sideflow and the gasket stayed in place.

Changes in gasket width, depending upon the gasket material, may require changes in unit load to maintain constant compression. An increase in the width of a rubber gasket adds material. This additional material increases internal resistance to flow. To offset this resistance, unit loads must be raised. This is not the case with truly compressible materials such as cork-and-rubber. They do not sideflow appreciably so changes in width have little effect.

Changing gasket thickness may also have an effect on gasket compression. A ½" straight rubber gasket that compresses about 20% under 280 psi will require almost 1000 psi for the same per cent compression if its thickness is reduced to ⅛". With cork-and-rubber, however, changes in the ratio of load area to free area affect stress-strain curves only slightly. Consequently, it is unnecessary to increase unit loads to maintain constant compression when the thickness of compressible materials is reduced.

• • •

There is an Armstrong Composition designed to meet each of the six grades in MIL-G-6183 (formerly AN-G-32) covering cork-and-rubber materials. For information on new gasketing materials being developed to meet special military requirements, call your Armstrong representative . . . or write.

See Armstrong's Gasket Materials manual in Sweet's file for product designers for other design suggestions covering both joints and gaskets. For personal copy of this manual, write to the Armstrong Cork Company, Gaskets and Packings Department, 7107 Arch Street, Lancaster, Penna.

ARMSTRONG'S *Gasket Materials*

DO NOT LUBRICATE
Murderous shock duty is imposed on the motor on this log barker. Conventional cast motors broke shafts, feet, brackets. The steel frame Life-Line stands up . . . has reduced outages to zero . . . saved costly replacement.
FOR THE BEST DESIGN
USE Life-Line
WESTINGHOUSE
RESET
Other makes of starters, previously tried, couldn't "stand the gaff" on this cinder block-making machine. Here, where vibration is severe, standard Life-Linestarters performed without fail. Operation requires opening and closing of starter over 240 times every hour.

Jarred?

These two can take slam-bang abuse

How many times does your design call for something extra in a control . . . or a motor? Extra ability to withstand vibration, shock, physical impact, for example. Here's a pair—matched in ability to meet these conditions.

Take the Life-Linestarter.® Vibration or accidental impact does not cause false operation with resultant contact pitting. That's because it employs an inverted, clapper-type design in which a movable element is pulled against a stationary magnet. Contact opening does not depend on gravity. Positive kickout spring speeds operation.

Now, the Life-Line motor. The severe stresses of heavy loads which must be transmitted through the motor frame and feet are easily withstood by the Life-Line steel frame. There's no distortion of laminations. What's more, steel adds strength without adding bulkiness. In fact, Life-Lines are as much as ⅓ smaller for the same frame size. You save space, weight; you gain strength.

Remember it costs no more to get Life-Line performance. Specify this pair on your future designs. More information? Simply call your Westinghouse representative. He'll give you complete facts . . . help you with any problems. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-21626

YOU CAN BE SURE . . . IF IT'S Westinghouse

Life-Line MOTORS and CONTROLS

Arm rest shells by Hungerford Plastics Corp., Murray Hill, N. J., and Industrial Plastics Co., Division of Industrial Abrasives, Inc., 1829 So. 55th St., Chicago 50, Ill.

HOW TO GET A BETTER GRIP ON COSTS!

Combination grips and arm rests for Studebaker car doors achieve a goal everybody is seeking—maximum owner comfort and easier fabrication at lower cost. Thanks to resilient, *one-piece* shells of VINYLITE Elastomeric Plastics. They are extremely easy to fabricate, they prove again how easy it is to cut production time and expense—and get a better product.

They explain, too, why so many producers of essential defense and civilian products are turning to VINYLITE Elastomeric Molding and Extrusion materials for grommets, tubing, hoses, sockets, pedals, bumpers, shelf supports, intricately shaped parts of a thousand descriptions.

These economically formed materials, available in all colors, resist stains, dirt, mildew, water, oils, greases, alkalies, and most strong acids. They lower production costs, simplify assembly, and last a lifetime.

You'll learn lots more about them from the booklet "VINYLITE Resins and Plastics—Extrusion and Molding Materials." Write Dept. KR-10 for your free copy.

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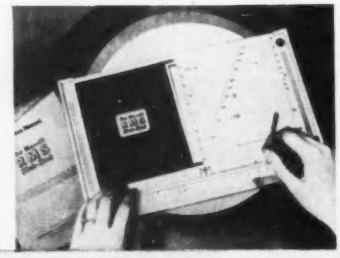
PLASTICS

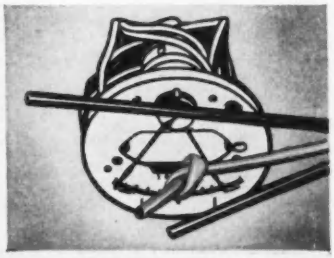
TRADE MARK

BAKELITE COMPANY
A Division of
Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.

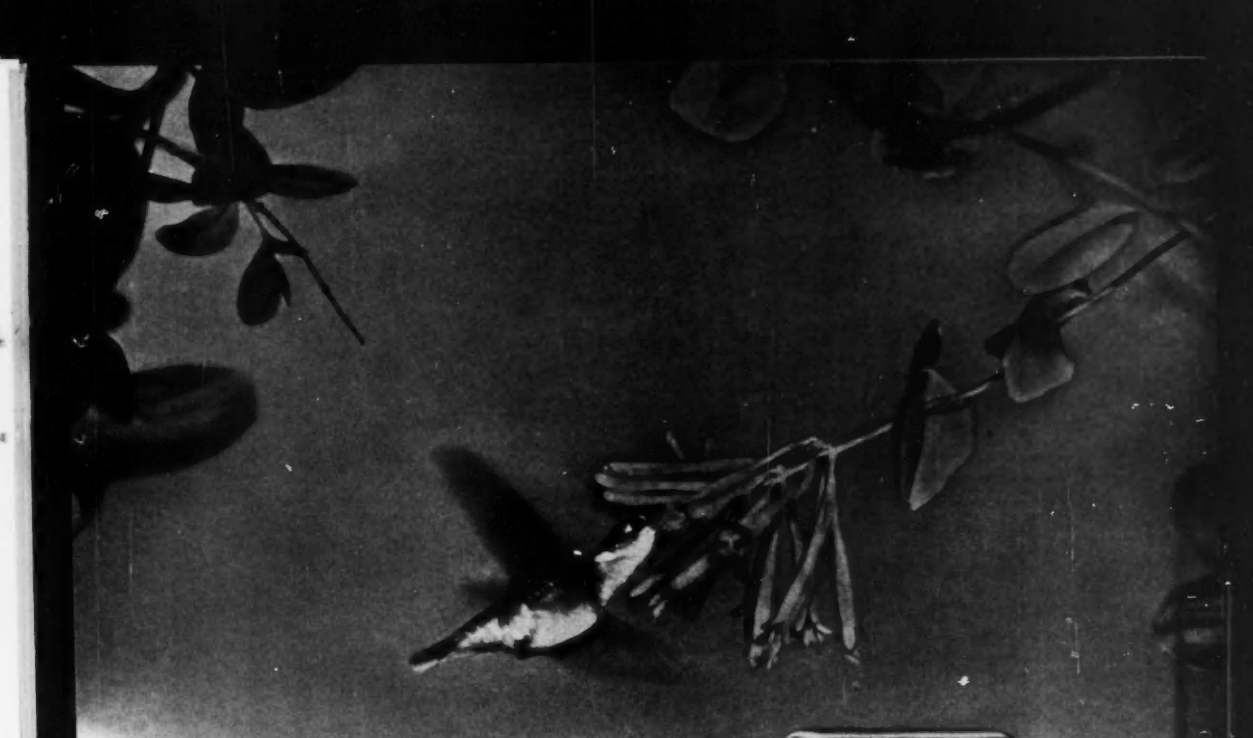
PEAK DEPENDABILITY. Vital military and civilian radios, machine tools, planes, control circuits stay on the job longer with wires and cables insulated or jacketed with VINYLITE Plastics and Resins. Strongly resist heat, cold, grease, water, mildew, aging, corrosive atmospheres.



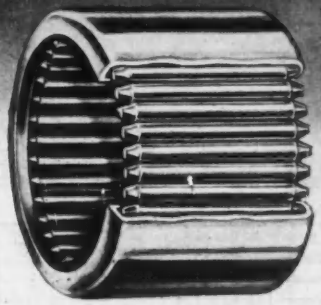
DIMENSIONALLY STABLE. Quickly solving statistical problems, this "Merrill RMS Slide-Disk" calculator has critical parts of VINYLITE Rigid Sheets that hold size, shape, resist wear, chemicals. Pleasant feel. Easy to clean. By Graphic Calculator Co., 633 Plymouth Ct., Chicago 5, Ill.



HIGH DIELECTRIC STRENGTH is held by this electrical insulating tubing even if twisted, knotted, exposed to heat. Made of VINYLITE Plastisols and glass fibers at low cost. Cuts clean. Non-flammable. Many colors. Resists oil, water, most chemicals. Bentley, Harris Mfg. Co., Conshohocken, Pa.



compact...



Torrington Needle Bearings fit in tight places. These efficient units have the smallest O.D. in relation to radial load capacity of any anti-friction bearings.

This combination of compact size and high capacity has proved an important design advantage from the standpoint of space-savings and weight reduction. Products utilizing Needle Bearings are models of simplicity and efficiency.

If your application requires compactness coupled with high capacity, get acquainted with Torrington Needle Bearings. We'll be glad to help you adapt them to your specific needs.

THE TORRINGTON COMPANY

Torrington, Conn. • South Bend 21, Ind.

District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON *NEEDLE* BEARINGS

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • STRAIGHT ROLLER • BALL • NEEDLE ROLLERS

Can You Use a HEAVY liquid?

Can you use a heavy liquid that has contributed greatly to simplifying design and fabrication of certain products?

Acetylene tetrabromide is an unusually heavy liquid with a specific gravity of 2.95. In the absence of sunlight, acetylene tetrabromide is stable in dry air. And, when sealed in an opaque container, it will not break down.

Acetylene tetrabromide is comparatively inexpensive and finds wide use as a gauge fluid and as the movable part in vibration dampeners. It is also used for mineral separation by specific gravity.

GIVE A SEARCHING LOOK at the properties of acetylene tetrabromide. Then, if you desire further information or technical service, write or wire Dow.

$C_2H_2Br_4$ →

Properties:

Clear, colorless liquid with a mild sweet odor.

Specific gravity at 25/25°C.	2.953
Pounds per gallon at 25°C.	24.57
Boiling point at 15 mm. Hg	119°C.
Freezing point	0.0°C.
Fire point	None
Flash point	None

Solubility, grams per 100 grams solvent:

Alcohol at 25°C.	∞
Carbon Tetrachloride at 25°C.	∞
Chloroform at 25°C.	∞
Ether at 25°C.	∞
Water at 30°C.	0.065
Water at 80°C.	0.28

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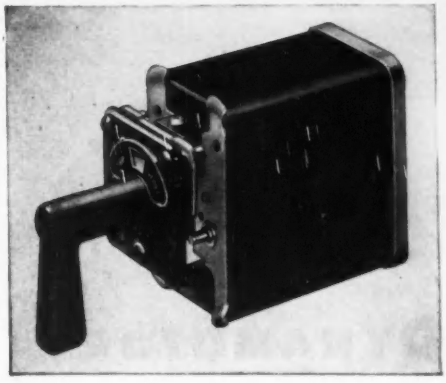
DOW CHEMICALS
INDISPENSABLE TO INDUSTRY AND AGRICULTURE

Versatile switch simplifies control of huge hot strip mill

86 in. Hot Strip Mill, Kaiser Steel Corporation



Another job made easy by G-E

SB CONTROL AND TRANSFER SWITCHES

RED HOT STEEL STRIP races at more than 2,000 ft. per minute from the big mill of the Kaiser Steel Corporation at Fontana, California. Precision control of speed, tension, width, thickness and the flying shear which cuts the steel "on the run" requires many circuit-sequence combinations. Sturdy General Electric SB switches provide the necessary versatility and assure reliable performance.

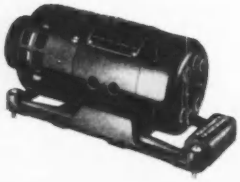
THIS IS JUST ONE EXAMPLE of the thousands of control installations made easy with the compact, versatile family of SB-type switches. By varying the cam and finger arrangements and number of stages, design engineers have utilized the General Electric SB-1-type switch, for example, with over 10,000 circuit-sequence control combinations. Standard parts and simple basic design mean long life and dependable operation.

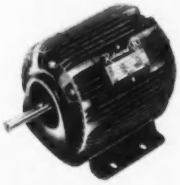
FOR FURTHER DETAILS see your G-E sales representative, or write for Bulletin GEA-4746, Section 856-76, General Electric Company, Schenectady 5, N. Y.

856-76

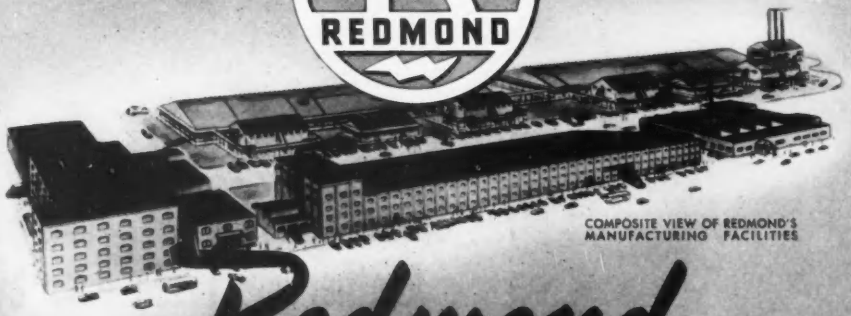
GENERAL ELECTRIC

COMPLETE MANUFACTURING AND ENGINEERING FACILITIES FOR MILITARY REQUIREMENTS





REDMOND



COMPOSITE VIEW OF REDMOND'S MANUFACTURING FACILITIES

Redmond

MICROMOTORS, DYNAMOTORS

WINDSHIELD WIPERS and other SPECIAL EQUIPMENT

Once again the Redmond Company is ready to serve in the mass production of military equipment . . . ready to offer the kind of cooperation you need in product development and manufacturing.

Here you gain the benefits of the Redmond research engineers with broad experience in developing special motors, dynamotors and many other devices for military applications.

Here you get a service keyed to high volume production techniques . . . an organization that has produced more than 35,000,000 Redmond Micromotors. This uninterrupted high production is assured by Redmond's 3000 thoroughly trained employees.

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REDMOND COMPANY, INC., Owosso, Mich., U.S.A.

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THE BIG NAME IN SMALL MOTORS

Design Department:
Couldn't we use plastics to advantage, too?
J. B.

Versatile properties to meet our specifications.

Monsanto can give us a whale-of-a lot of help. Let's get in touch with them!

"For years, we've been helping leading refrigerator manufacturers discard habit-itis*", says W. B. Wallace of Mack Molding Company, Arlington, Vermont, "by molding *better* refrigerator parts made of Lustrex styrene plastic."
*habit-thinking in design and materials engineering

"We helped refrigerator manufacturers do it better, faster, at lower cost...with plastics"

Today, plastics are basic materials in many industrial applications. The refrigerator industry, for instance, looks to Lustrex styrene plastic for *seven* different types of component parts *because* Lustrex has inherent advantages over other materials for such applications.

For the refrigerator manufacturer, Lustrex provides these special advantages: 1. outstanding production economies; 2. unimpaired strength at low temperatures; 3. dimensional stability; 4. excellent thermal and electrical insulating properties; 5. light weight; 6. low water absorption; 7. freedom from taste and odor; 8. smooth, lasting surface finishes; 9. crystal clarity (transparency); 10. a broad range of color possibilities.

If you're considering plastics for some important industrial use, perhaps Monsanto can help you. For in addition to Lustrex styrene plastic, there is a whole big *family* of Monsanto plastics—each with its own special characteristics useful for particular applications. In addition, Monsanto can put you in touch with competent plastics molders and fabricators (like Mack Molding Company and many others); or counsel you on your materials problems (write to Monsanto Plastics Technical Council). Monsanto Chemical Company, Plastics Division, Room , Springfield 2, Mass.

Lustrex Reg. U. S. Pat. Off.

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MONSANTO CHEMICAL COMPANY, Plastics Division,
Room 2107 Springfield 2, Mass.

☐ Please send me information on the big Monsanto family of plastics.
☐ Please send the name of plastics molders who can help me.

Name & Title

Company

Address

City, Zone, State

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WITH BENDIX SCINFLEX ELECTRICAL CONNECTORS

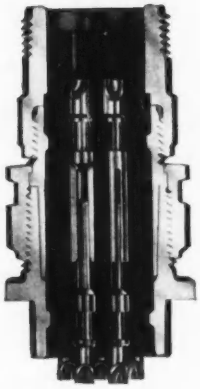
PRESSURE TIGHT SOCKET CONTACTS

PLUS

- Moisture-proof
- Radio Quiet
- Single-piece Inserts
- Vibration-proof
- Light Weight
- High Insulation Resistance
- Easy Assembly and Disassembly
- Fewer Parts than any other Connector
- No additional solder required

Outstanding design and precision workmanship assure completely pressurized electrical connectors for all sizes of contacts. A truly important feature, but only one of the many exclusive advantages that contribute toward making Bendix outstanding in the electrical connector field. Increased resistance to flash over and creepage is made possible by the use of Scinflex dielectric material—an exclusive development of Bendix. In temperature extremes, from —67°F. to +275°F. performance is remarkable. Dielectric strength is never less than 300 volts per mil. Remember, for the greatest value in electrical connectors, it pays to specify Bendix. Our sales department will gladly furnish complete information on request.

PLUS



SHELL
High strength aluminum alloy . . . High resistance to corrosion . . . with surface finish.

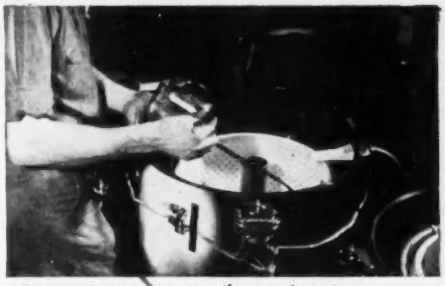
CONTACTS
High current capacity . . . Low voltage drop.

SCINFLEX ONE-PIECE INSERT
High dielectric strength . . . High insulation resistance.

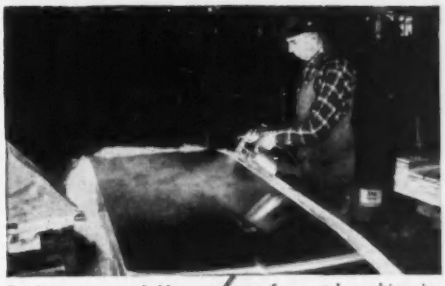
Pin and socket arrangements available for all sizes of contacts.

Bendix

SCINTILLA MAGNETO DIVISION of



Adhesives eliminate screws, nails and rivets in many operations. Here a 3M adhesive is being applied to the rim of a washing machine prior to laying a rubber trim gasket to seal the cover when the machine is in operation.



Coatings are remarkable cost-cutters for metal working industries. Coatings protect metal from scratches and abrasions during fabricating, storing and shipping, eliminating extra repolishing. And they strip off *easily!*

ADHESIVES COATINGS SEALERS

3M COMPANY

Sealers in the aircraft industry meet tough operational requirements. This weatherproof sealer—being applied around the wing root fillet of a jet fighter—provides a resilient seal at sonic speeds, at temperatures down to —80°F.

YOUR 3M SALESMAN HAS 1000 ANSWERS TO YOUR STICKY PROBLEMS

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Beyond actual products, 3M offers *service.* Our research and development facilities are set up to help you find the right answer to your problem. 3M field engineers come into your plant and fit the *right* formula into your production . . . and stay until it is working!

These elements of experience, service, and thorough knowledge of adhesives, coatings and sealers, make it profitable for you to look to 3M for the solution of your adhesive problems. For prompt help on your adhesives problems, contact your 3M salesman or write directly to 3M, Dept. 47 in Detroit. Write also for our valuable, informative adhesives booklet.

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In ACF-Brill Coaches, it's Heim Unibal Spherical Bearing Rod Ends

ACF-Brill trackless trolley coaches have set remarkable records for economy of operation and performance.

The Heim Company is justifiably proud of the fact that Heim Unibal Spherical Bearing Rod Ends were chosen by the ACF-Brill Motors Co. because they have demonstrated their ability to perform under the most difficult conditions.

Use Heim Rod Ends in linkage mechanisms for the transmission of force and motion from one machine component to another.

Please write for complete catalog of Heim Bearings and Rod Ends.

THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

USE THE MOTOR that Cleans Itself

YOU CAN CUT DOWN on motor cleaning operations and greatly reduce inspections and overhauls on the equipment you design. Tests have proved that on most applications totally-enclosed, fan-cooled motors more than pay back their extra cost in reduced maintenance. And this new Allis-Chalmers Type APZ tefc motor makes maintenance costs lower than ever before on this type of motor.

Here's Why

Concealed air passages and pockets have been eliminated; dirt cannot build up to cause overheating. Cooling air is blown over the ribbed cast iron frame and bearing housings carrying dirt away with it. How about oily dirt that sticks? It can be wiped or blown off without stopping the motor.

Rigid Construction

The frame is rigid cast iron which not only has high inherent corrosion resistance, but also holds bearings permanently in alignment. Bearings are prelubricated at the factory and should need no attention for years. Tapped holes with pipe plugs to permit regreasing and to provide grease relief are standard equipment.

Get All The Facts

The new Allis-Chalmers Type APZ totally-enclosed, fan-cooled motor is built in all NEMA standard frame sizes from *224 to 505. Also in explosion-proof type. Your A-C Authorized Dealer or District Office offers you competent engineering aid on your design problems. Call today, or write Allis-Chalmers, Milwaukee 1, Wisconsin. Ask for Bulletin 51B6144.

A-3402

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CONTROL — Manual, magnetic and combination starters; push button stations and components for complete control systems.

TEXROPE — Belts in all sizes and sections, standard and *Vari-Pitch* sheaves, speed changers.

PUMPS — Integral motor and coupled types from ¾ in. to 72 in. discharge and up.

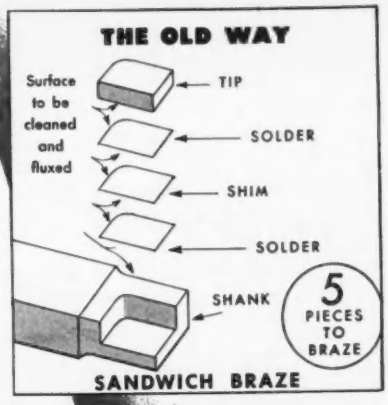
Texrope and *Vari-Pitch* are Allis-Chalmers trademarks.

ALLIS-CHALMERS

*Similar design non-ventilated motors Type APK, also available in frames 203 to 224 inclusive.

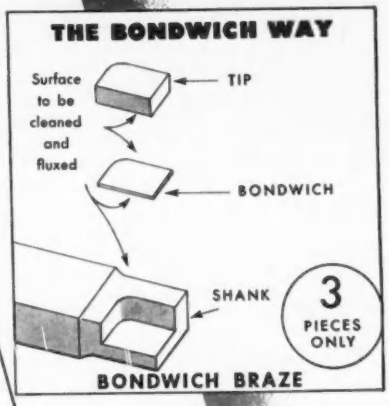
Problem:

How to Speed Up Sandwich Brazing Carbide Tool Tips



General Plate:

Provided the Solution with "BONDWICH"... a Composite Metal Combination



Carbide tipped tools give best results if the tip is brazed to the shank by sandwich brazing. However, the disadvantage of this method is the work involved in cleaning, fluxing, and positioning the three separate pieces of brazing alloy and shim material in addition to the tip and shank.

General Plate engineers solved the problem by bonding *into a single sheet* the three mentioned pieces. The result . . . a *General Plate composite metal* called "BONDWICH."

The two outer layers of "BONDWICH" are brazing alloy . . . the center piece a ductile shim. The bond is so perfect that when the brazing temperature is reached, complete wetting takes place. There are minimum voids in the final braze as the evenly wetted shim carries the braze all over. In addition to providing a better braze, "BONDWICH" speeds up carbide tip tool brazing, cuts production costs.

No matter what your metal problem, it will pay you to consult with General Plate. Their vast experience in cladding precious to base metals or base to base metals can overcome your problems . . . often reduce costs.

General Plate Products include . . . Precious metals clad to base metals, Base metals clad to base metals, Alcuplate (copper and aluminum), Silver Solders, Composite contacts, buttons and rivets, Platinum fabrication and refining, Age-hardenable #720 Manganese Alloy. Write for information.

Have You a Composite Metal Problem?
General Plate can solve it for you

GENERAL PLATE

Division of Metals & Controls Corporation
17 FOREST STREET, ATTLEBORO, MASS.

As the white outline indicates, a standard unit of much greater frame size would be required to do the work of Speedaire.

Speedaire-equipped agitator built by Buflovak Equipment Division, Blaw-Knox Company.

SPEEDAIRE agitator drive saves $267

HERE'S another equipment builder who uses Speedaire because it is compactly designed, lighter in weight and lower in cost. Compared to the conventional worm gear drive required to operate this steam jacketed vertical agitator, Speedaire offers these advantages:

1. It occupies only one-third the space,
2. It weighs less than half as much,
3. It saves $267 per unit in cost.

Speedaire is Cleveland's fan-cooled worm-gear speed reducer. Because it is fan-cooled, Speedaire will do more work —will deliver up to *double the horsepower* of standard worm units of equal frame size, at usual motor speeds. It can be installed economically on many applications where other types have been used heretofore—giving you the advantage of a compact right-angle drive. Speedaire gives the same long, trouble-free service characteristic of all Clevelands.

For full description, send for Catalog 300. The Cleveland Worm & Gear Co., 3279 E. 80th St., Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

CLEVELAND
Worm Gear
Speed Reducers

New Home of BGR Springs at Plymouth MICHIGAN

On and after September 1, 1951—our new plant, 40300 Plymouth Road, Plymouth, Michigan will take over the operations of our former Detroit Plant.

The ever-growing demand for our product has made necessary this move into larger quarters. On our new site of 50 acres, we have completed a modern one-story factory that will enable us to double the productive capacity of our old Detroit Plant, and consequently increase to a greater extent our service to customers.

After Sept. 1, please direct all correspondence to:

Barnes-Gibson-Raymond Division
Associated Spring Corporation
P. O. Box No. 555, Plymouth, Michigan

Business continues as usual at Cook Plant of B-G-R at Ann Arbor, Michigan

This move in no way affects the operation of our Cook Plant, Ann Arbor, Michigan which will continue the same as in the past.

BARNES-GIBSON-RAYMOND

DIVISION OF ASSOCIATED SPRING CORPORATION

40300 Plymouth Road
Plymouth, Michigan
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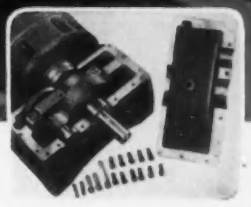
2 plants for SPRING SERVICE

Cook Plant • 401 E. Stadium Blvd.
Ann Arbor, Michigan
Tel. 3-4258

what to look for in a gearmotor

1. Remove end cap



2. Remove gear case cover

look for

Horizontal Split Case Construction

Many hours of service and maintenance time are saved by this split case construction—an exclusive Westinghouse feature. The parting line of the case is on the center line of the bearings. This provides easy accessibility without the necessity of disturbing the motor, mounting or driven machine.

Two simple operations are all that are required to open the Westinghouse Gearmotor for inspection or servicing: (1) Remove end cap, (2) Remove gear case cover. A man and a wrench can complete the operation in record time.

The long service life of Westinghouse Gearmotors saves you time and money, too. High-quality components that assure you trouble-free performance include:

Taper-hardened helical gears for high efficiency and smooth, quiet operation.

Anti-friction bearings for permanent shaft alignment and minimum friction loss.

A simple splash-type oil system for positive and ample lubrication.

Bulletin DB-3600-H contains complete product information and application data on all Westinghouse Gearmotors. Write for your copy today. Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pa.

J-07301

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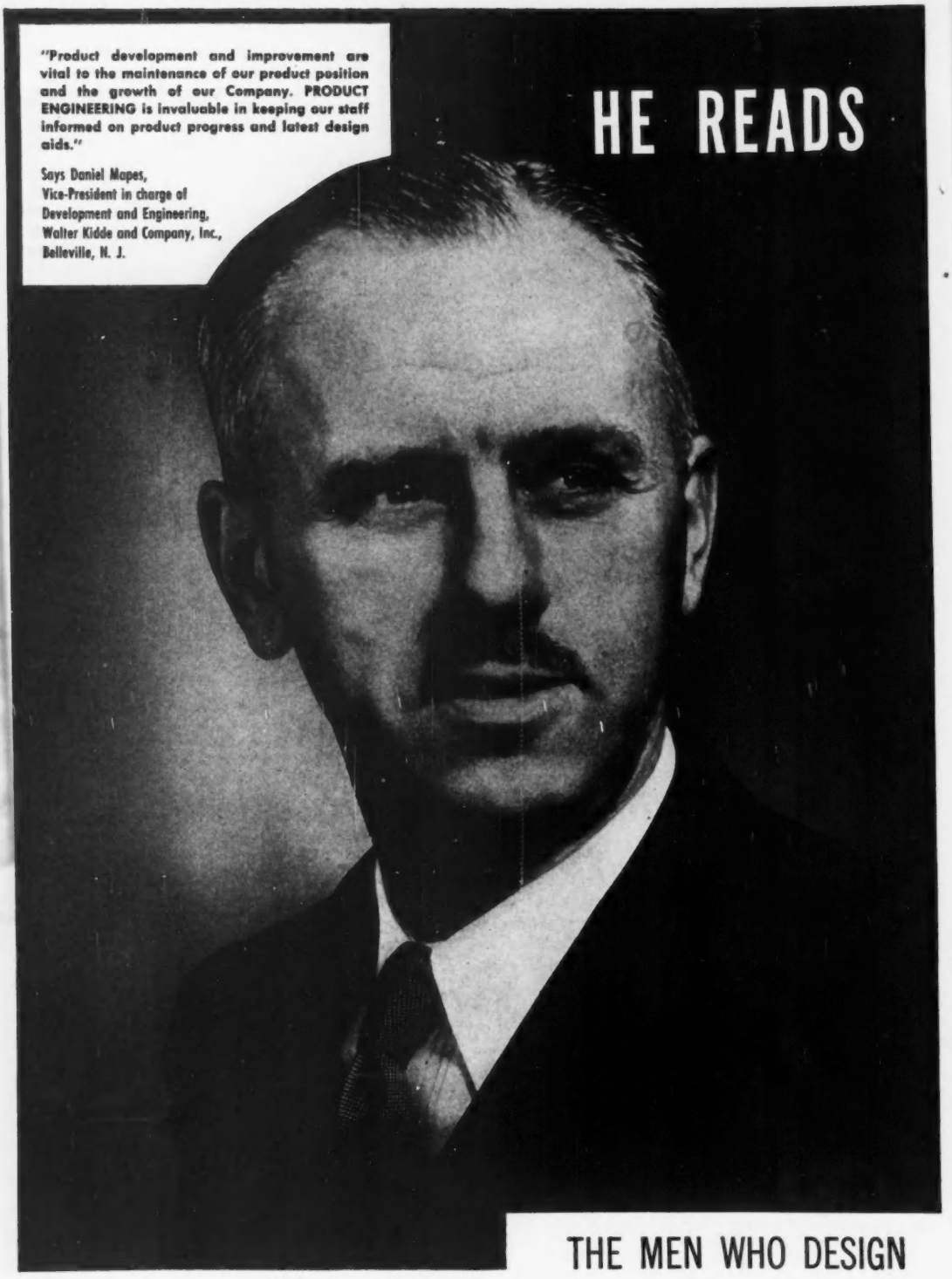
MEMBER OF AGMA

GEARED DRIVES

HE READS

"Product development and improvement are vital to the maintenance of our product position and the growth of our Company. **PRODUCT ENGINEERING** is invaluable in keeping our staff informed on product progress and latest design aids."

Says Daniel Mapes,
Vice-President in charge of
Development and Engineering,
Walter Kidde and Company, Inc.,
Belleville, N. J.



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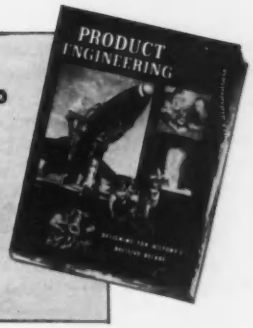
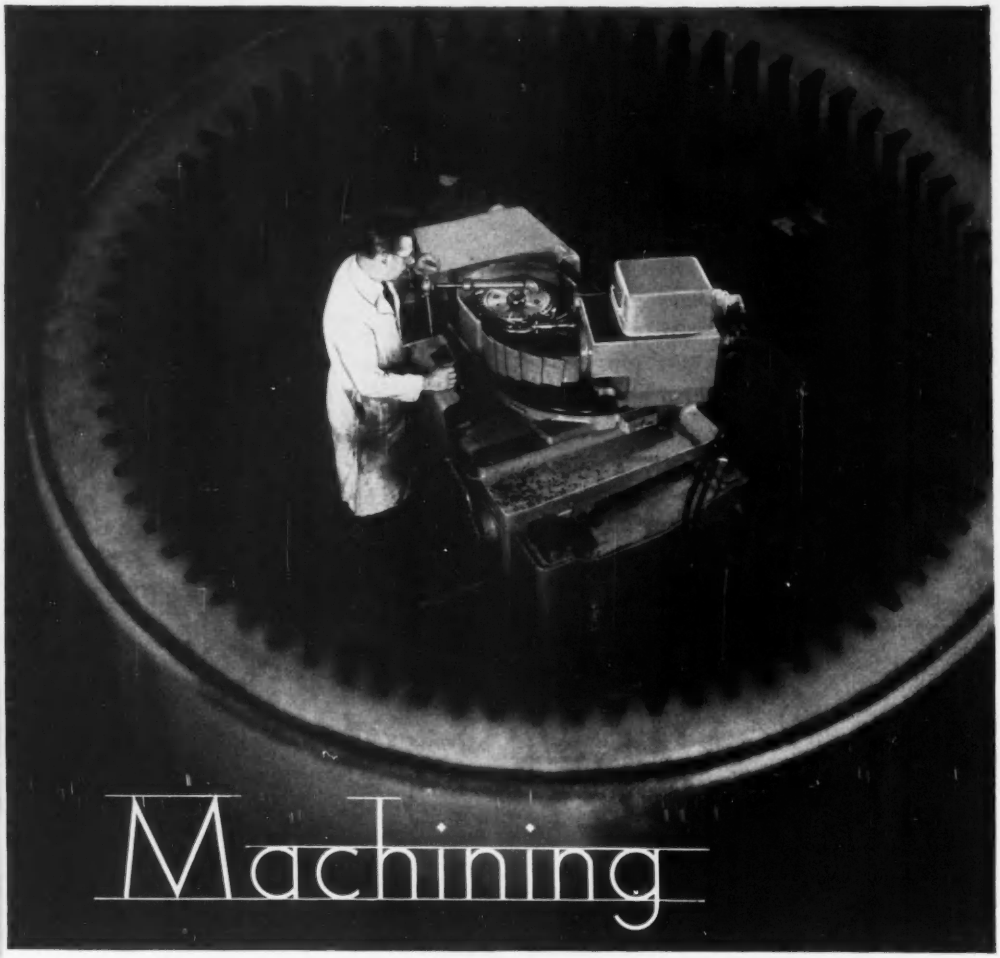


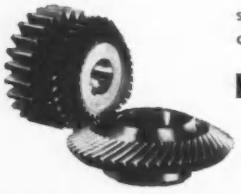
AMERICA'S NEW PRODUCTS READ PRODUCT ENGINEERING



of gears is a matter of fitting competent men and efficient machines to the job. One machine may be used to make a variety of gears. But the quality of some types it produces might suffer . . . or the cost might be higher.

• Here at BRAD FOOTE . . . in our own plant . . . we have an assortment of gear-making machines each of which is used to make gears within certain specifications. This enables us to turn out a volume of gears while positively controlling quality and price. Our highly skilled workers subscribe to and uphold the BRAD FOOTE creed—"*No one shares our responsibility.*"

• So when you specify BRAD FOOTE gears—for use in your shop or on the equipment you sell to others—you can be sure of satisfactory performance.



BRAD FOOTE GEAR WORKS, Inc.

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Cicero 50, Illinois

Materials ~ AVAILABILITY AND TRENDS

NON-FERROUS POWDER

Non-ferrous metal powder producers report sufficient capacity to handle present demand. Up to this time no production expansion has been contemplated. Current publicity on the savings of metal to be obtained by using powder parts in lieu of machined parts might increase demand sufficiently to warrant some expansion. Some metal fabricators are still practicing willful waste by using oversize stock for small machined parts readily adaptable to a process that eliminates waste and is more economical.

IRON POWDER

Iron powder producers are off on a spree. Foreign interests in the U. S. are increasing. German powder manufacturers are now shopping around. They have a new method of producing powder which is a variation of the atomization process. Swedish interests have already completed production facilities in New Jersey. Domestic companies are intent upon meeting all foreign competition. Most major producers are expanding facilities.

The possibility of an all-out war is not so obvious that subsequent enlarged military demands for iron powder rotating bands should warrant such eager expansion. Powder producers are evidently confident of a larger civilian market. Recent improvements, such as copper alloy infiltration of iron and steel parts and the use of volatile salts in plating, have stimulated interest in this material.

A source of uncontrolled steel exists in the metal powder field. Iron powder is not a controlled material. Steel parts are produced by the fabricator by the addition of graphite to the powder prior to pressing and sintering.

THERMOSETTING RESIN SUPPLY

The consistantly expanding plastics industry continues to grow at a pace which might soon offset present shortages. Raw materials rather than fabrication facilities constitute the shortage. In the thermosetting end of the industry, current and proposed expansion of phenol production is expected to close the gap between supply and demand by the end of 1951. By mid-1952 the total anticipated production will be approximately 500 million pounds. This is considerably in excess of the present demand of 375 million pounds. However this doesn't seem to worry the plastics industry since increased demand is also expected. At present over 70 percent of the phenol production is consumed by the plastics industry.

A tenuous balance between demand and availability of urea exists due to imports and increased production. No shortage of urea molding materials is anticipated this year or next.

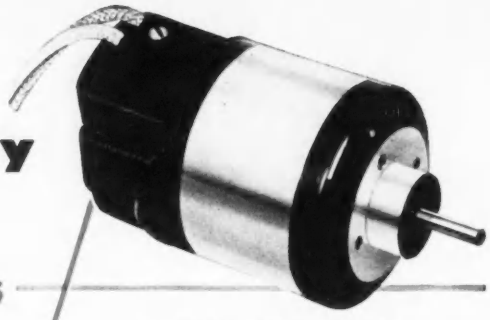
MELAMINE RESINS SHORT

The melamine resins face the most serious shortage due primarily to the demand by the military for large amounts of calcium dicyanamide used in the manufacture of nitroquanadine for explosives.

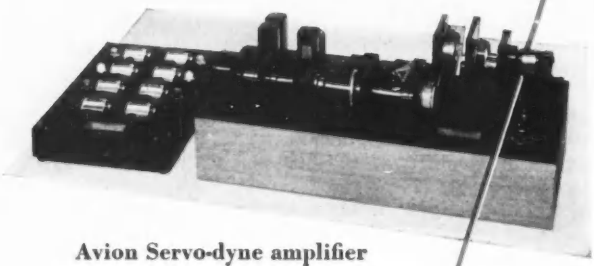
Previous expansion in plastic raw materials manufacture has been based upon faith in the plastics industry. Although generally this faith has been justified, the present emergency calls for more caution and better knowledge to prevent the industry from overselling itself.

(*continued on page 97*)

Developed especially for application in aircraft controls



the Holtzer-Cabot 0810 sub-miniature DC servo motor



Avion Servo-dyne amplifier

Holtzer-Cabot's RBDS-0810 sub-miniature DC servo motor was designed and engineered especially for service in highly sensitive aircraft controls and instruments.

A typical application of this special motor is its use with the Avion Servo-dyne amplifier. The sub-miniature combination of amplifier and motor reduces the size and weight of remote positioning systems in airborne computers and instruments indicating flight conditions.

The model 0810 performs efficiently at altitudes ranging from sea level to 40,000 feet, in temperatures varying from −65° F. to +160° F. and in relative humidity up to 100%. It is a 4-pole motor, measuring only 1⅝" in diameter and $2\frac{9}{16}$" over bearing hubs and weighs but 8½ ounces.

Operating on a normal field current of 6 milliamperes, the motor's armature is separately and continuously excited from a DC source of 24.3 to 29.7 volts. The field assembly consists of two independent high impedance windings, and this assembly is hermetically sealed.

The RBDS-0810 motor provides practically noiseless, variable-speed, reversible operation. It has a very low inertia rotating element for fast response, and delivers a maximum of 1/500 horsepower.

This achievement in small-motor efficiency is further evidence of Holtzer-Cabot's ability to develop and produce fine precision motors for exacting applications.

Specialized engineering skill combined with 75 years' manufacturing experience enable Holtzer-Cabot to build motors to the most demanding specifications.

For additional information write for Bulletin 0810.

HOLTZER-CABOT

DIVISION OF NATIONAL PNEUMATIC CO., INC.

BOSTON 19, MASSACHUSETTS

"Manufacturers of fine electrical apparatus since 1875"

THERMOPLASTICS

This branch of the industry has been moving along nicely. Increased production of thermoplastic materials has continued in spite of the high initial investment for plant expansion. An overall increase in manufacturing facilities of from ten to twenty percent is expected this year.

Vinyl manufacturers can't go along with the rest of the plastics industry on this matter of expansion. The rapid changes in the resins and compounds among the vinyls in the past decade have resulted in a very high rate of plant obsolescence. An optimistic outlook for vinyl production consequently does not exist.

IMPROVED POLYSTYRENE

Increased application of polystyrene is expected in the near future as a result of findings of the Manufacturing Chemists Association Plastics Technical Sub-committee research project at MIT. Some former users of polystyrene who gave up on the material due to its low tensile strength, poor resistance to abrasion and tendency to craze or crack under stress would do well to keep abreast of these developments.

ZINC NEEDS HELP

The youthful ambition of the plastics industry in its eagerness to expand in spite of high costs is not shared by the zinc industry. Help from Uncle Sam is shamelessly requested. At the 33rd annual meeting of the American Zinc Institute it was mentioned that zinc supply can be brought into line with requirements by 1953 through the following: Increased production through incentive bonus payments for new and expanded production; expansion of the industry by tax relief through accelerated amortization; exploration assistance to develop new ore reserves.

LACQUER SUPPLY ADEQUATE

Nitrocellulose lacquer manufacturers are proclaiming a distinctive advantage for their product over other production line finishes--ready availability. Reasons given for such availability are: The existence of large scale production capacity for nitrocellulose and finished lacquers--sufficient to satisfy military and essential civilian demands; flexibility of lacquer formulations which makes them independent of any one or any group of critical materials.

Modern lacquer formulations are being considered by the military for applications now specifying synthetic enamels. Hot spray techniques have stimulated interest due to decreased cost and application time and better coverage. However, the military interest stems mostly from the fact that it can be obtained.

LEAD IMPORTS SHORT

The increased demand for lead is not the only factor contributing to a shortage of supply. Imports which have comprised about one-third of our total supply have all but terminated due to a disparity between world and domestic prices. Foreign consumers pay the higher world market price and consequently get the lead. Some governmental action is needed to alleviate the situation. So far, nothing has been done and supply remains extremely tight.

STORAGE BATTERY OUTLOOK

Hardest hit by the lead shortage are the storage battery manufacturers. Inventories of less than one week have been reported. The battery industry is asking for special considerations in addition to price parity. Their supply problem would be partially solved if battery manufacturers were permitted exclusive use of their own reclaimed lead rather than sharing it with lead-consuming industries which do not produce scrap. This could start quite a trend. Another consideration requested is an amendment to NPA Order M-38 to recognize seasonal variations in consumption by the industry. Under the present order, production to meet only half of the civilian requirements is possible. The battery manufacturers can take solace in the fact that they are not alone in requesting Washington to get the lead out.

HOW TO ASSEMBLE AIR FILTERS WITH *Clean 40% Savings*

As told by TRION, INC.
McKees Rock, Pennsylvania

"Our cost department has advised me that they have calculated a 40% savings in assembly time due to the use of SPEED NUTS®," writes Mr. E. W. Meyers, Jr., President of Trion, Inc.

"In addition to the actual savings in cost, SPEED NUTS permit disassembly of our Trion Electric Air Filters, as installation and operating conditions may require. Other fastening methods would not provide this flexibility of design.
"Another very tangible savings in using SPEED NUTS is the lack of shipping difficulties caused by vibration loosening of parts."

In this letter, Mr. Meyers emphasizes three of the most outstanding SPEED NUT assembly advantages —time-saving, design flexibility, and minimized shipping damage. There are many more. Chances are your product can be improved and your costs cut by these versatile fasteners. A Tinnerman Fastening Analysis will show you how. Write today for details and your copy of the new "Savings Stories" booklet. TINNERMAN PRODUCTS, INC., Dept. 12, Box 6688, Cleveland 1, Ohio. In Canada: Dominion Fasteners Ltd., Hamilton. In Great Britain: Simmonds Aerocessories, Ltd., Treforest, Wales.

Air filter panels are attached with Flat Type SPEED NUTS and screws. Fast, easy attachments made in limited working space. SPEED NUTS tighten down without being held with wrench.
TINNERMAN
Speed Nuts

Manpower Problem

ALMOST EVERY COMPANY is facing a serious manpower problem in their engineering department. The various means being used in attempting to solve this problem range all the way from trying to circumvent it to a sincere effort to arrive at a sound solution.

Farming out layout and drafting work to outside companies that specialize in that field has been found to be a highly satisfactory solution for quite a few companies, both large and small. Many of these services are of the highest caliber. They not only produce the required drawings, but are also capable of handling much of the layout and designing of details.

The national economy and specifically the clients of these companies benefit. These engineering and drafting services carry the peak loads and thereby enable their clients to maintain a more stable engineering department with references to the personnel employed. This means that the client companies can offer a better assurance of a steady job to the members of their engineering organization. Hence there will be less turnover in the engineering department, which gives the opportunity to train and build men for the key positions.

Obviously, the above contributes nothing to the solution of the overall problem on a national scale. The only complete solution is one which makes available to the country a greater number of men and women qualified to do the engineering work required. From this angle, the long term solution is to train more people in colleges and institutes. Unfortunately, the shortages of manpower exist today and the immediate need is to solve the problem quickly.

H. L. Gantt, one of the outstanding pupils of Frederick Winslow Taylor, who introduced management engineering, was a great exponent for the development of trained employees. His slogan was, "Every man in an organization must be given the opportunity to do the biggest job that he might be capable of handling. When a man is qualified to do a far bigger job than the one that he is doing it is a mark of managerial inefficiency."

At least one of our large national companies is applying this very principal to quickly build the productive power of their engineering department. The procedure is simple. All of the jobs to be done in the engineering department are listed and analyzed closely. The abilities and experiences required for each of the jobs are carefully determined. The capabilities of each person in the department are studied carefully. With this analysis as a basis, everyone in the engineering department is upgraded to the point where he or she is producing at the highest level commensurate with his abilities. Lowest level jobs are then filled with trainees obtained from high schools, institutes, and the colleges, according to the abilities required.

This method of solving the manpower shortage in the engineering department has many virtues. It recognizes the responsibilities of management to train employees. Management gives each employee the greatest possible opportunities for advancement. Such a plan also does much to lift the morale of the men in the engineering department to the highest levels. And finally, it is making the best possible use of available manpower and thereby contributes to the productivity of the nation. It is a sound solution that promises great benefits to all concerned.

G. F. Zodenholt

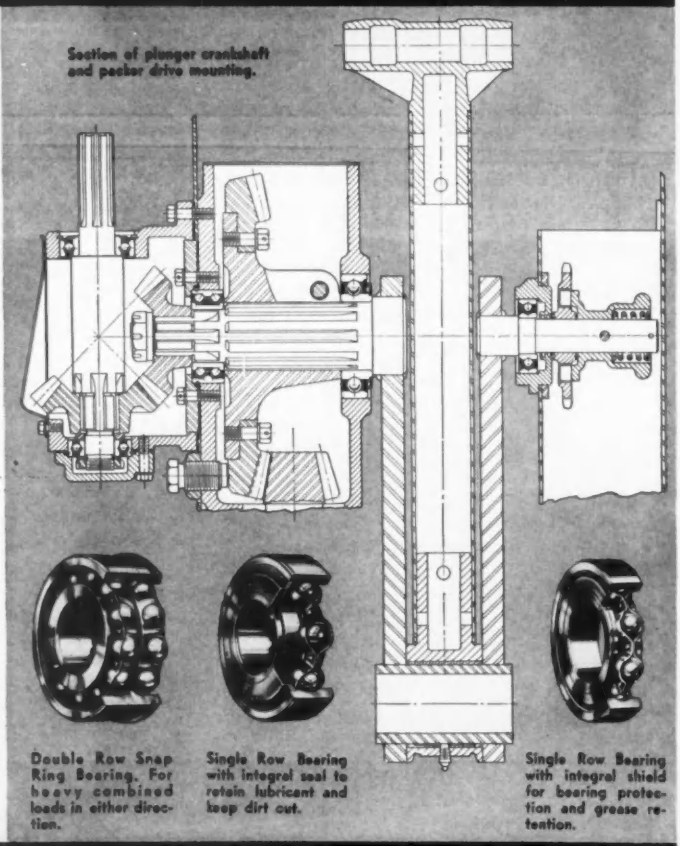
The Right Bearings for Better Baling

• In the McCormick No. 45 Automatic Pickup Baler, producing up to 5 tons of perfectly baled hay per hour, New Departure ball bearings in the main drive hold shafts and gears always in accurate relationship under rapidly fluctuating loads of crankshaft and plunger operating at 65 strokes per minute.

Ball bearings help to streamline and greatly simplify details of design. No provisions are needed for bearing adjustments and, by the use of bearings with integral seals or shields and snap rings for axial location, parts are kept plain and strong — fewer members are required.

Because of their ability to take thrust loads from either direction in a single, unit bearing in addition to radial loads, endwise location of each shaft is by one bearing only. Remaining bearings are free of any possible cramping action due to expansion changes under load.

The No. 45 Baler employs eleven New Departure ball bearings in various positions for smooth operation and long machine life.


Section of plunger crankshaft and packer drive mounting.
Double Row Snap Ring Bearing. For heavy combined loads in either direction.
Single Row Bearing with integral seal to retain lubricant and keep dirt out.
Single Row Bearing with integral shield for bearing protection and grease retention.

Nothing Rolls Like a Ball

NEW DEPARTURE BALL BEARINGS

NEW DEPARTURE · DIVISION OF GENERAL MOTORS · BRISTOL, CONNECTICUT

Corrosion Factors in Design

Factors contributing to the corrosion of metals. Methods of minimizing attack under six types of exposure.

FRED M. REINHART
National Bureau of Standards

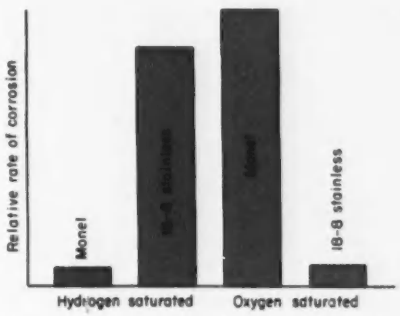


Fig. 1—Relative corrosive effects on stainless steel and Monel metal due to either dissolved oxygen or hydrogen in 3 percent sulphuric acid. In hydrogen-saturated acid, Monel has good corrosion resistance while 18-8 stainless steel is more durable in contact with oxygen-saturated acid.

THE RATE AT WHICH CORROSION PROCEEDS is influenced by a number of factors, such as: acidity, oxidation, temperature, agitation, and impurities in the corrosive solution; also in the metal: surface conditions, stress, heat treatment, joining dissimilar metals, and fabricating methods. Corrosion seldom stems from any single one of these factors and consequently, the designer must understand the full effect of all factors to make a satisfactory product.

ACIDITY OF SOLUTIONS is determined by the concentration of hydrogen ions (*pH*) in solution. It is an important factor in the corrosion of metals. Some metals react more to alkaline solutions where the *pH* value is greater than 7.0, while others when the *pH* value is low. For example, steel is corroded in acid solutions while aluminum alloys are rapidly corroded in alkaline solutions.

PRESENCE OF OXIDIZING AGENTS can greatly influence the rate of corrosion. In some cases, an oxidizing agent accelerates corrosion while in others, it simply retards corrosion by the formation of oxide films.

Certain metals and alloys such as 18-8 Cr-Ni alloy steel and aluminum readily form oxide films which protect them from corrosion under oxidizing conditions. Under reducing conditions (where oxygen is absent) these films are easily broken down thus exposing the bare metal to corrosive attack. Stainless-steel is resistant to corrosion in sulfuric acid saturated with oxygen but is readily corroded when the acid is saturated with hydrogen. As shown in Fig. 1, Monel metal has exactly the reverse behavior.

SURFACE FILMS are products of corrosion that are insoluble in the corroding medium and may form a solid impermeable film over the metal. This film may have properties appreciably different from those of the corrosive solution. Readily visible films, insoluble in the corrosive medium but usually permeable by water, are often sufficiently dense to reduce the flow of fresh corrodent to the metal and in this way decrease the rate of corrosion.

On the other hand, some films may increase the rate of corrosion in the atmosphere by causing the retention of moisture or corrosive vapors. If the film is non-uniform and discontinuous, it may allow the active solution to remain in contact with the metal, forming a concentration cell which would severely pit these localized areas. Some films contain corrosion products which dissolve in the solution thus making the solution more corrosive. Films which are hygroscopic cause corrosion in the atmosphere at humidities in which the metal surface would normally be dry

and not seriously affected.

Other films, usually very thin and composed principally of oxides of the metal, are quite impermeable to corroding mediums. These passive or cathodic films occur on aluminum and its alloys and on the chromium-nickel austenitic corrosion resistant steels.

TEMPERATURE generally tends to increase the rate of corrosion, but under certain conditions an increase in temperature may cause a decrease in the corrosion rate. The protective films, upon which most metals and alloys depend for resistance to corrosion, may be destroyed by heating.

In Fig. 2, the rapid increase in the corrosion of lead in hydrochloric acid due to a rise in temperature is shown.

The solubility of many salts and chemical compounds decreases with a drop in temperature. Under this condition, salts may precipitate and deposit on the metal surface forming a protective scale or film. As long as this film remains insoluble, it serves to protect the metal from further corrosion. A temperature rise may affect the rate of corrosion (depending on the metal) by lowering the solubility of air in the solution.

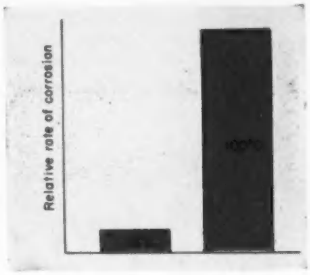


Fig. 2—Temperature greatly influences the corrosion of lead in hydrochloric acid

1. Atmospheric Corrosion

Corrosion of exposed metals varies greatly and depends on the atmospheric conditions. The principle natural constituents affecting atmospheric corrosion are: moisture, oxygen (air) and carbon dioxide. Corrosion in industrial and urban areas is primarily due to compounds of chlorine and of sulfur. Chlorine compounds in the atmosphere originate in sea waters and are concentrated in narrow belts along the shores; their activity rapidly decreases with the distance from the coast line.

Sulfur compounds, the biproducts of fuels, are more prevalent and active than any other corrosive constituent in the air except moisture and oxygen. Being gases, these compounds drift farther from their sources and are more active in atmospheric corrosion than the chlorides, although in solutions the reverse is true. Analysis of corrosion in coastal cities shows a preponderance of sulfates; only in shore locations are the chlorides in excess.

Ordinarily, the sulfur compounds are in a "reduced" state when first exposed to air, commonly occurring as hydrogen sulfide and sulfur dioxide. If these gases come into contact with buildings, soil or vegetation, they are rapidly removed by adsorption; however, if they remain in moist air, these gases are oxidized into sulfuric acid which is adsorbed on dust particles or carried as independent microscopic drops. Contact with metals results in the formation of sulfates of the metals. Most metal sulfates are hygroscopic and by absorbing moisture will promote a continuing type of corrosion.

The presence of any solid or liquid particles in the air also is conducive to corrosive attack. Such bodies collect moisture along with other active corrodents and are air-borne until they contact metal surfaces. When settled on the metal, they produce small concentration cells which hasten corrosion. These particles may set up galvanic cells if they are of suitable composition and conductivity.

Many solids which deposit on metals and most of the deposits of corrosion products have the property of absorbing moisture at relative humidities much less than 100 percent. There is a critical humidity upon which corrosion is dependent; with humidities below the critical value, corrosion is either nil or low while above it corrosion progresses rapidly. This critical humidity differs with the metal and the corrosion product. For many copper materials, it is nearly 100 percent; for certain nickel products it is above 85 and about 65% for iron or steel.

Microscopic particles of dry sea salt or drops of salt-saturated water may exist at fairly low humidities and be carried some distance before settling or being adsorbed. Where the humidity is not exceptionally low, this saturated solution will deposit on metal surfaces which are not directly warmed by sunlight. If it dries in

2. Under-Water Corrosion

Natural Waters

Corrosive effects from natural waters are largely the result of dissolved materials. The corrosive action of such water depends principally on the acid content, gas content, ability to form films, the temperature and velocity of the water.

Waters which have been in contact with soils containing decomposed animal and vegetable matter produces water with a sufficiently high acid content which readily reacts with and rapidly corrodes many metals. Waters in contact with soils low in acid are likely to be alkaline and not corrosive to most metals. However in some cases, alkaline waters may dissolve salts or absorb oxidizing agents and thus become quite corrosive.

One of the most variable corrosive constituents of water is the dissolved oxygen. Variations in oxygen content of natural water often cause differences in the corrosion rates by several hundred percent. Dissolved oxygen in the water of closed systems, attacks the metal which rapidly depletes the oxygen and thus loses its corrosive power. As long as this system does not require appreciable additions of water, no further corrosion takes place.

Where sufficient acid is present in water, the corrosion rate increases in proportion with the entrained oxygen up to an optimum oxygen to acid ratio, as well as the water velocity. If this optimum ratio is exceeded then the corrosion rate diminishes; this reverse action where the metal surfaces become passive may be due to the formation of a protective film. On the other hand, this passive condition may be considered as the result of large cathodic areas of concentration cells caused by the reaction of oxygen. Such cathodic effects exist

VELOCITY of a corrosive solution moving past a metallic surface tends to accelerate the rate of corrosion due to the increased supply of oxygen brought into contact with the metal surfaces. An increase in velocity of a solution also increases the removal of corrosion products, which otherwise might accumulate and stifle the rate of corrosion. Higher velocities mean thinner surface films through which the corrosive medium must penetrate. Thus the movement of the solution may either prevent the formation of protective films or may remove such films once they have been formed.

Under many conditions of flow, particularly where gas bubbles are in solution, a serious type of pitting attack may occur. Such pitting is always associated with turbulent flow.

USE OF INHIBITORS—Inhibitors frequently are added to corrosive solutions in small amounts to retard or prevent the corrosion of metals. Brine solutions used in refrigeration are corrosive and are frequently inhibited with sodium dichromate to prevent the deterioration of the equipment. Most automobile antifreeze solutions contain inhibitors to retard the corrosion of the engine block, water pump and radiator.

The influence that these factors have on the corrosion rate of a metal actually depends on the types of corrosion involved. These can be classified as:

1. Atmospheric corrosion
2. Fresh or sea water corrosion
3. Galvanic corrosion
4. Concentration cell corrosion
5. Stress corrosion
6. Fretting corrosion

place, a film of salt is left which will readily absorb moisture from clear air and renew its corrosive effect when the critical humidity is reached.

Minimizing Atmospheric Corrosion

1. Use rounded corners and contours wherever possible; sharp corners should be avoided where moisture, liquids and solid matter can accumulate.

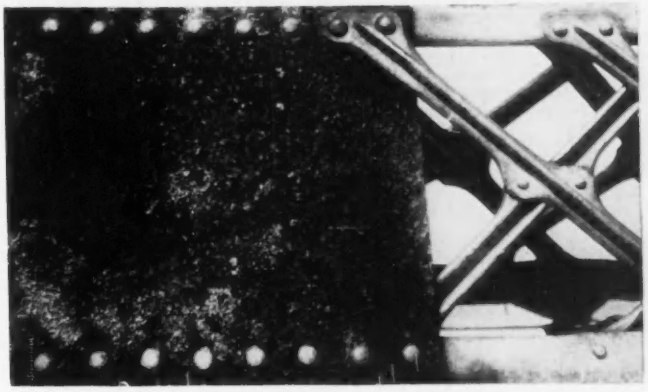
2. Place construction angles, channels, H and I beams, in a way to avoid catchment areas for liquids; otherwise, drainage holes should be provided.

3. Use the most corrosion-resistant metals within service and cost requirements: Consider "Clad" materials. Frequently, thinner sections of corrosion-resistant metals are more economical by giving longer service.

4. Apply metallic coatings by spraying, hot dipping or electrodepositing; most common coatings are: zinc, lead, cadmium, nickel, chromium, copper, and aluminum.

5. Use butt welded joints in preference to lap joints. If lap joints must be used, all exposed edges should be either filled with a non-absorbing caulking compound, or welded or soldered to prevent the access and retention of liquids in crevices.

6. Support tanks and storage containers on legs to allow free circulation of air beneath container to prevent condensation of moisture.

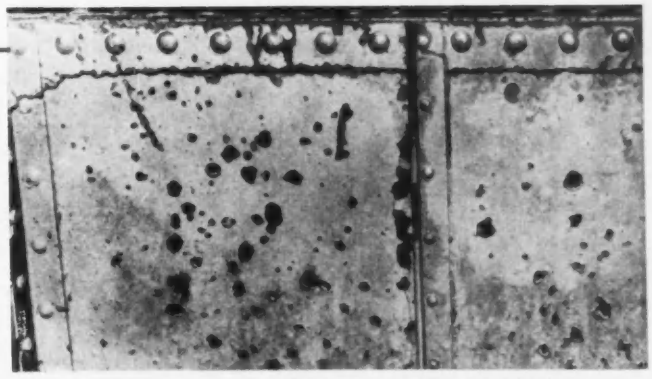


Composite aluminum-steel girder after three years of atmospheric exposure shows the extent of corrosion on the steel end-plates.

without anodic areas and thus inhibit corrosion.

In natural waters, saturation contents of calcium carbonate aid in the protection of steel by the precipitation of a basic carbonate film. Many natural waters also contain sufficient silicates to form similar protective coatings. For this reason, certain silicates are often added to water.

Reduced sulfur compounds, chiefly hydrogen sulfide, are often present in water coming from deep wells and are very corrosive. Since waters from great depths contain little or no oxygen, the corrosive action is due to



Tidewater corrosion of a painted magnesium alloy (aircraft wing) after only 31 days of exposure. Cracks are due to stress corrosion.

the acid reaction alone. With dissolved oxygen, the form of corrosion changes entirely and the rate of deterioration is usually greater.

Fresh waters of rivers are often polluted; corrosion in these instances is dependent upon the pollutants and should be considered in the class with chemical corrosion. Frequently the corrosive effects of the pollutants are only partially direct since they may react with organic and mineral contents of the river bed and introduce such gases as carbon dioxide, hydrogen sulphide or sulfur dioxide which may be very corrosive.

Sea Waters

Most sea water corrosion occurs in harbors where the waters are more variable in composition than that of the open sea and contain impurities such as acids, oxidizing agents and sulfur-bearing organic agents. In addition, the dilution of harbor waters, by rain or city waste waters produces an unsaturated condition with respect to calcium carbonate and other film-forming constituents, thus preventing the formation of protective films.

Sea water corrosion is complicated by the presence of animal and vegetable life. It is usually saturated with oxygen near the surface which gradually decreases with depth. This decrease is accentuated by marine growths which use oxygen. In addition, many marine growths such as barnacles adhere to metal and set up concentration

3. Galvanic Corrosion

An electrical potential difference can be measured between metals forming a galvanic couple and this difference varies with each corrosion condition such as the metals, electrolyte and temperature. The potential difference between two metals indicates the tendency for current to flow and the rate of corrosion depends upon the quantity of current generated. In Table I, two positions are indicated for certain alloys; the position (active or passive) depends upon the corrosion media; whether an oxidizing solution or one containing activating ions, such as halides.

This galvanic series indicates only the tendency of the metals and alloys to set up galvanic corrosion. Actual corrosion cannot proceed unless there is a flow of electrical current. This current flow is dependent on such basic factors as:

1. Conductivity of the circuit
2. Electrical potential between the anode and cathode
3. Polarization factor
4. Relative catode-anode area
5. Geometrical relationship between dissimilar metal surfaces
6. Contact between metals.

Conductivity of the Circuit: A closed electrical circuit between the metals and the solution is necessary to effect corrosion. In the case of tap water which contains dissolved ionizable salts and other relatively low-conductivity solutions, the galvanic influences are usually localized so that the less noble metal (anode) corrodes in the immediate vicinity of the more noble metal (cathode). Strong salt or highly ionized solutions of other chemicals, including acids and alkalies are good conductors, and under proper conditions galvanic corrosion can take place over a wide area. Such corrosion is likely to affect the entire anode surface.

Electrical potential between anode and cathode is determined by the relative position of metals in the galvanic series. In the absence of other controlling factors, corrosion varies directly with the voltage. However, current density and polarization often more greatly influence the rate of corrosion than the potential difference.

Polarization may be considered as a change in the amount or direction of current flow in an electrolytic cell. It may occur either at the anode through the accumulation of corrosion products, such as metallic ions or at the cathode through the deposition of hydrogen. Of these two types of polarization, the latter (cathodic polarization) is most often the controlling factor. Hydrogen is a poor conductor of electricity and any accumulation acts as an insulator; this reduces the electromotive force (*emf*) of the cell and galvanic corrosion will cease. The reverse reaction or depolarization may take place under certain conditions where dissolved oxygen in the electrolyte unites with the deposited hydro-

Table I—Galvanic Series of Common Metals and Alloys

1	Magnesium and its alloys ANODIC (most easily corroded)	17	Lead	34	Chrom. steel (12-18%) P
2	Zinc	18	Tin	35	Stainless (types 301, 304, 309) P
3	Aluminum 52S—4S—3S—2S	19	Nickel A	36	Chromium steel (23-30%) P
4	Alclad Aluminum alloys	20	Ni-Cr-Fe Alloy A	37	Stainless steel (types 310, 316) P
5	Cadmium	21	Inconel A	38	Silver
6	Aluminum A17S, 17S, 24S	22	80-20, Ni-Cr alloy	39	Graphite
7	Carbon Steel	23	Brasses	40	Gold
8	Wrought iron	24	Copper	41	Platinum—CATHODIC (most noble)
9	Copper bearing steel	25	Bronzes		
10	Cast iron (grey)	26	Nickel silver		
11	Chromium steel (4 to 6% Cr)	27	Copper-nickel alloys		
12	Chromium steel (12-30%) A	28	Monel		
13	Ni-Resist	29	Silver Solder		
14	Stainless types 301, 304 A	30	Nickel P		
15	Stainless types 309, 310, 316 A	31	Ni-Cr-Fe alloy P		
16	Lead-tin solder	32	Inconel P		
		33	80-20, Ni-Cr alloy P		

A signifies active condition of metal. This condition is dependent on the corrosion medium with respect to their oxydizing powers and acidity or to the presence of activating ions such as halides.

P signifies passive condition of metal.

cells. Although the barnacle's interior is free from any corrosives, particularly dissolved oxygen which might act directly on the metal, the shell forms a conducting screen which keeps the interior anode and its solution separated from the cathodic solution outside. Alloys which do not contain appreciable amounts of copper are frequently deeply pitted by barnacles.

In spite of the wide variations in the condition of sea water there are surprisingly small differences in the corrosion of common metals and alloys when they are exposed to corrosion by sea water throughout the world.

Reducing Under-Water Corrosion

1. In welding, the weld metal should be cathodic (more noble) compared to the base metal (See Table I).
2. Precautions should be taken to insure tightness of lap joints.
3. When possible, special under-water paints should be used.
4. Baffles and stiffeners inside tanks should permit free drainage.
5. Bottoms of tanks should be rounded or sloped with rounded corners.
6. Drain-out valves and plugs should be flush with the tank bottom.
7. Whenever possible, cathodic protection should be considered: consisting of suspending magnesium rods in critical regions or by impressing a slight electromotive force.

gen to form water, and thus allows the galvanic corrosion to proceed.

Relative cathode and anode areas do not influence the initial difference in potential between two metals. However, it is the current density that affects the rate of corrosion. This density depends largely upon the relative surfaces of the two metals. A small anode area and a large cathode area cause an increase in current density on the anode which corrodes. On the other hand, if the area of the anode is large compared with that of the cathode, the current density on the anode will be less and the corrosion rate will be decreased. This is illustrated in Fig. 3. As an example, a steel rivet (anode) in a copper plate (cathode) is rapidly attacked in sea water; a copper rivet in a steel plate does not accelerate the corrosion to any appreciable extent. In each case the electrical potential difference is the same but the current densities on the anodes result in different rates of corrosion.

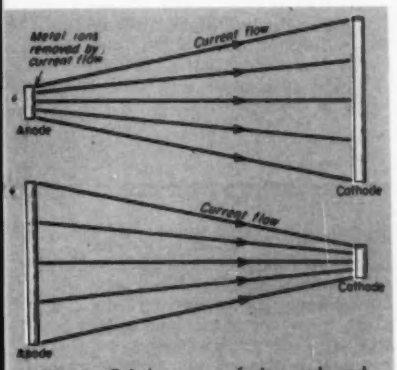
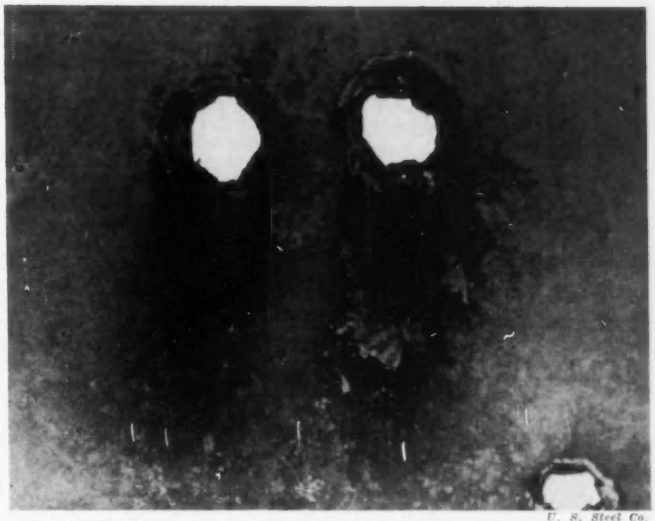


Fig. 3 — Relative areas of the anode and cathode affect the corrosion rate. Smaller anodes mean greater current density on the anode, which increases the rate of corrosion.



U. S. Steel Co.

Nickel plated steel after 3½ years in fresh water is corroded through due to pinholes in the 0.001 in. plating.

Dissimilar metal surfaces affect the rate of galvanic corrosion depending on their position in relation to each other. Most frequently these metals make line contact; the intensity and distribution of the galvanic effect will be determined principally by the conductivity of the electrolyte. Occasionally, dissimilar metals are not held in contact; in this case, the distance between the metals and the conductivity of the electrolyte are of equal importance in causing galvanic corrosion.

Contact between metals is necessary to permit maximum current flow because of the relatively low voltages involved. Such contact must be practically metal-to-metal, for oxide films or corrosion products between overlapping pieces of metal may be sufficient insulation to prevent galvanic corrosion. The presence of a conducting liquid or a dried salt bridge between two metals will not take the place of a truly metallic conductor.

Controlling Galvanic Corrosion

1. Do not join dissimilar metals which are widely separated in Table I.
2. Avoid the use of small anodic areas. Use more noble metals for small fastenings, bolts and rivets.
3. Insulate joints of dissimilar materials; paints increase the resistance of a galvanic circuit.
4. For outdoor exposure, make faying surfaces water tight.
5. When possible, paint or coat all surfaces. Avoid painting the less noble metal alone for defects in coating may be severely attacked because of the area-ratio effect.
6. Use bare zinc, aluminum or magnesium anodes in the electrolyte close to surfaces which require protection.
7. Use metallic coatings to reduce the contact potential of dissimilar metal surfaces.
8. If possible, use chemical inhibitors in the electrolytic solution.

4. Concentration-Cell Corrosion

This type of corrosion occurs when two or more areas on the surface of a metal are exposed to different concentrations of the same solution, thus setting up differences in electrical potential. When such a solution consists of salts of the metal itself, existing in different concentrations at different locations along the metal surface, it is known as a metal-ion cell. This condition is illustrated in Fig. 4 where the corrosive solution at the faying surface of the joint is relatively stagnant as compared to that surrounding the crevice. In the outer region, metal will dissolve and enter the solution as metal-ions. The concentration of these ions in the crevice becomes higher than that outside because of the movement in the larger volume of solution. Whenever a higher metal-ion concentration exists in one region than in another, an electrical potential is created between the two points; the region with the higher concentration is cathodic. Current leaves the metal at the point of lowest potential and passes through the solution to the point of highest concentration of metal-ions where it again enters the metal. In this process, metal-ions are carried into solution at the point where the current leaves the metal causing a localized attack or pitting.

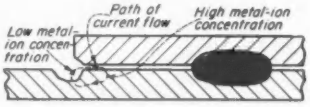


Fig. 4—Concentration-cell corrosion at the faying surfaces of a spot welded lap joint. Electro-chemical current flow removes metal at the low-metal ion region which causes pitting.

Solutions containing varying amounts of dissolved air or oxygen form a destructive type of concentration cell, called the oxygen-cell. A deposit, crevice or sharp corner that prevents the diffusion of air into the solution in these areas will result in difference in dissolved oxygen in the solution. The result is accelerated corrosion beneath the deposit or within the crevice or corner. A typical oxygen concentration cell is illustrated in Fig. 5. In the oxygen-cell, the flow of current is opposite to that in the metal-ion cell; current flows through the solution from the metal inside the crevice to the metal outside.

In some instances oxygen cells develop into much more powerful and

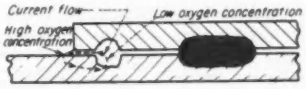


Fig. 5—Oxygen-Cell in a crevice of a spot welded lap joint. Current flow is reversed as compared to the metal-ion cell of Fig. 4. Metal is corroded at the low-oxygen region inside the joint.

5. Stress Corrosion

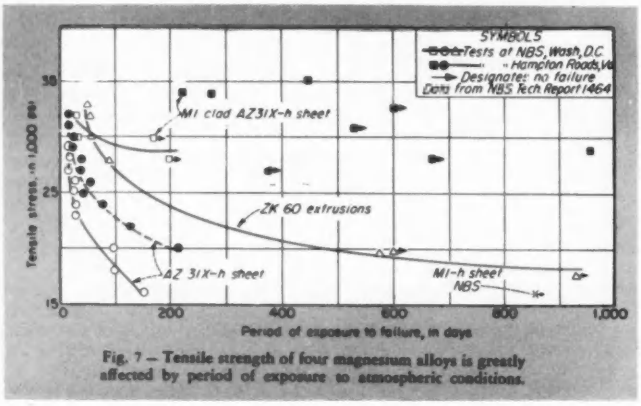


Fig. 7 — Tensile strength of four magnesium alloys is greatly affected by period of exposure to atmospheric conditions.

The combined effects of stress and corrosion on the behavior of metals is considered as stress corrosion. Only static tensile stresses have been found to influence stress corrosion cracking. Failure of this type are due to the corrosive attack which causes pits that generally extend perpendicular to the direction of the tensile stress component; such pitting results in stress concentrations. This stress concentration causes the metal to crack at the base of the pit, thus exposing fresh metal to further corrosive attack. These mutually accelerating effects finally result in complete failure of the metal. Fig. 7 illustrates the loss in strength of several magnesium alloy after a period of atmospheric exposure.

6. Fretting Corrosion

Rapid attack or deterioration that occurs between contacting, highly-loaded metal surfaces when subjected to very slight relative (vibratory) motion is called fretting or chafing corrosion. Both relative motion due to alternating stresses and presence of oxygen are necessary for its occurrence.

Fatigue failures often have their origin in the deep pits of a fretted area which act as a stress raiser. This type of failure has been found in many highly loaded machine parts such as shafts, splines, connecting rods, knuckle pins, clamped or bolted flanges and couplings. Figure shows a failed aircraft engine bracket due to frettings.

Fretting corrosion can occur between any two contacting materials if at least one of them is a metal. It may occur on either wet or dry surfaces. Under dry surface conditions, the best resistance to this type of corrosion is found when one of the metals was brass; the poorest resistance occurs when one metal is stainless steel. The best resistance under wet conditions, is obtained with nickel in combination with all metals except itself and the least resistance is with stainless steel in combination with other metals.

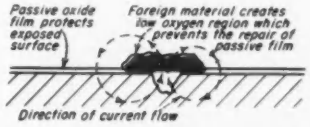
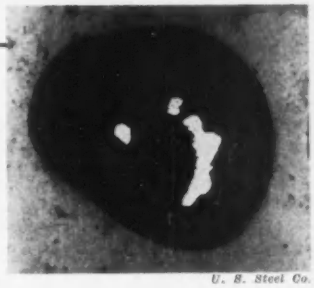

Passive oxide film protects exposed surface
Foreign material creates low oxygen region which prevents the repair of passive film
Direction of current flow

Fig. 6—Active-Passive Cell is the result of a low oxygen region which prevents the formation of a passive oxide film. Such corrosion affects stainless steel which depends on oxide films

destructive cells called active-passive cells. Such cells are prone to occur on metals which depend upon a tightly adhering oxide film for corrosion resistance such as the austenitic stainless steels. If an adequate supply of oxygen is available to heal any breaks which may occur and to maintain a continuous film, the metals are said to be in the passive state. If breaks in the film occur and are irreparable because of an oxygen deficiency, those areas become active. Deposits of foreign material on surfaces of stainless steel may render the areas under the deposits active and pitting will result. Fig. 6 illustrates a typical active-passive cell which can develop from an oxygen concentration cell. The intact film area with high oxygen concentration acts as the cathode of the cell and the area where the film is broken becomes active and acts as the anode. The current is due to the potential between the small active area beneath the deposit and the large passive area outside. If such deposits are removed periodically any breaks in the passive film will be permitted to heal and this pitting will be prevented.

Preventing Concentration Cell Corrosion

1. Avoid riveted or spot-welded lap joints. Use butt welded joints.
2. Seal all lap joints with solder, weld metal or caulking compound.
3. Avoid sharp corners, reentrant angles, pockets, or conditions which permit solids or liquids to collect.
4. Design liquid transport equipment for a minimum of turbulent flow and air or gas entrainment.
5. In contact with metal, do not use wood, insulation, or substances which absorb or retain liquids.



U. S. Steel Co.

The presence of a small pebble on the bottom of a galvanized chicken feeder trough caused this concentration cell corrosion.

Stresses may be internal or applied or a combination of both. Internal stresses are produced by several methods: cold working, unequal cooling from high temperatures, or internal microstructural rearrangements involving volume changes. Stresses caused by cold working, mechanically stressing, by shrink fits, and those induced during welding or other thermal treatments, may be classed as internal stresses. Such internal stresses are generally of greater importance under stress-corrosion conditions than those which are applied. If sufficiently high, these concealed stresses may complicate design computations because their magnitude is difficult to determine. Also, the magnitude of these stresses is different from point to point within the metal and minimum values vary considerably with the type of metal or alloy and its environment.

How to Avoid Stress Corrosion Failures

1. Relieve residual stresses by annealing.
2. Add suitable inhibitors to the corrosive medium.
3. Use surface coatings to protect structure from corrosive medium.
4. Paint magnesium alloys; use alclad aluminum alloys; apply electrodeposited coatings on other metals.
5. Heat-treat alloys to dissolve precipitated constituents; this may improve the resistance to cracking.
6. Induce compressive stresses at the surface by shot-peening, rolling, or swaging.
7. Consider cathodic protection of structures.

U. S. Steel Co.

This crack adjacent to a spot weld in a railroad refrigerator car brine tank was caused by stress corrosion.

Preventing Fretting Corrosion

1. Reduce relative motion by increasing the contacting force.
2. Increase the surface hardness of contacting metals.
3. Thoroughly lubricate contacting surfaces to completely exclude air.
4. Roughen surfaces to increase the friction and minimize slippage.
5. Induce residual surface stresses by shot blasting or cold working.

Fretting or chafing of clamping surface surrounding bolt hole served as a fatigue nucleus which resulted in failure.

CONDITIONS OF SERVICE

Although the problem of corrosion is rather complicated, in many instances it can be considerably simplified. The first requisite is to have complete and exact information regarding the application of a structure or device which is subject to corrosive conditions. With this information, the designer can specify the proper materials and incorporate corrosion preventative features into the design. Some details are illustrated on pages 158 and 159.

Optimum Gear Train Ratios For Instrument Servomechanisms

Ratio of motor speed to output shaft speed that gives the maximum excess motor torque available for driving a specified torque on an instrument servo. Practical method for designing gear trains to achieve a minimum moment of inertia.

L. N. CANICK
Staff Engineer, Servomechanisms, Inc.

IN THE DESIGN OF GEAR TRAINS for instrument servos, in which the torque available to drive the output shaft is not constant but is a variable function of the speed of the mechanism motor, the designer's problem consists of two essential parts: (1) Calculation of the optimum gear reduction; and (2) Designing a gear train of minimum inertia.

The optimum gear reduction is defined as that ratio of motor speed to output shaft speed that gives the maximum torque safety factor when the servo is producing a specified torque at a given velocity. The method for determining this optimum ratio, is inherently capable of any degree of accuracy. It also permits the designer to include in his calculations such factors as gear efficiencies and bearing friction torques.

For an example of how the method is applied, consider the system indicated by the block diagram Fig. 1. The input signal is an alternating voltage, which can be the measure of almost any physical property such as a shaft position, temperature, velocity, or force. The servo amplifier magnifies the input signal until sufficient power is available to drive the motor in the mechanism unit. The motor does work, through an appropriate gear reduction, in rotating an output shaft to a position determined by the input signal.

Table I—Range of Motor Torques and Speeds

Motor	Stall Torque, oz in.	Input Power, watts	No Load Speed, rpm
A	0.13	3	2300
B	0.32	5	6500
C	1.45	12	5300
D	2.35	21.2	5300
E	5.5	30.5	3050

During rotation of the output shaft a bucking signal is produced in the mechanism unit by a potentiometer, autosyn, or similar device geared to the output shaft. When the difference between the bucking signal and the input signal to the amplifier is zero, the amplifier produces no output and the motor stops.

The mechanism unit for the system is represented schematically in Fig. 2. Although not shown in Fig. 2, a limit stop is generally required to keep the position of the output shaft within a given range, or to keep the potentiometer wiper from running off its winding. In addition, a slip clutch is often employed to reduce the shock load on the gear teeth when the limit stops engage. Since the potentiometer measures the rotation of the output shaft, the clutch may not be placed between the potentiometer and the output shaft.

The motor to drive the mechanism unit and output shaft is selected on a consideration of torque, velocity, acceleration and stability requirements. In Fig. 3 characteristic curves are shown, and in Table I are given a range of torques and speeds, that are typical of those available in motors in general use.

With the coordinates of the torque-speed curve of the selected motor known, a first approximation of the optimum gear reduction ratio can be made by assuming that the velocity of the output shaft is constant, and that no energy losses are present in the mechanism unit.

Where

N_m = motor speed, rpm
N_o = output shaft speed, rpm
R = ratio of motor speed to output shaft speed
T_m = motor torque, oz in.
T_o = output shaft torque, oz in.

$$T_m = T_o/R \quad (1)$$

$$N_m = RN_o \quad (2)$$

By calculating values of T_m and N_m for different arbitrary values of R, plotting these T_m and N_m values as points on the torque-speed curve of the motor, and striking a curve through the plotted points, the optimum gear reduction can be determined graphically as shown in Fig. 4. The optimum gear reduction is the one that makes the ratio of motor torque available to torque required a maximum. In Fig. 4 this ratio is shown as a/b for a reduction gear ratio R_g equal to N_{mT}/N_o the value N_{mT} being read from the plot.

After the optimum gear reduction has been approximated using the foregoing assumptions, it can be corrected to include an acceleration for the output shaft.

Where

I = moment of inertia of the rotating elements as referred to the motor shaft, oz in. sec²

a = required angular acceleration at the output shaft at the specified velocity N_o, radians/sec²

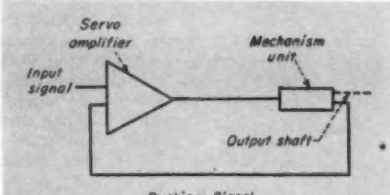


Fig. 1—Essential elements in a typical servomechanism system.

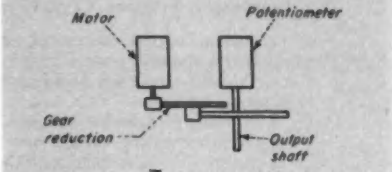


Fig. 2—Two step speed reduction train in a mechanism unit for a servo.

while the system is accelerating, Eq (1) becomes

$$T_m = T_a/R + aI/R \qquad (3)$$

To utilize Eq (3), it is necessary to design an approximate gear train from which a moment of inertia I can be computed. With this preliminary value of I, a plot similar to that of Fig. 4 is made but this time the values of T_m for arbitrary values of R are calculated by Eq (3). From this new plot, a second approximation of the optimum value of R is determined from the relations existing where the ratio of torque available to torque required is maximum.

If R has changed substantially from its first approximation, the gear train should be redesigned to obtain a better moment of inertia I and a third approximation of R determined. This procedure can be continued until the change in R is small between two successive approximations.

The moment of inertia, referred to the motor shaft, of a gear train depends upon the value of each gear step, materials, and distribution of material in the space occupied by the block form of each pinion and gear.

Using the schematic gear reduction train, Fig. 5, an approximate method will be presented for selecting the first and second steps of a two pass gear train for minimum inertia to satisfy a given value R, that is, for a specified gear reduction ratio.

Where

D_1 = diameter of first gear referred to the first pinion with the diameter of the first pinion taken as unity

m = diameter of second pinion referred to the first pinion

D_2 = diameter of second gear referred to the first pinion

c = moment of inertia of the first pinion of unit size

p = design constant for inertia of first gear, this constant is proportional to gear thickness and material density

q = design constant for second gear, not necessarily the same as p

the reduction of the first step is D_1, the reduction of the second step is D_2/m, and the total reduction R equals D_1D_2/m. The gear train inertia I measured at the motor shaft is

$$I = c + (pc\ D_1^4 + cm^4)\ (1/D_1)^2 + (qc\ D_2^4)\ (1/R)^2 \qquad (4)$$

substituting $m\ R/D_1$ for D_2 results in

$$I = c + pc\ D_1^2 + \frac{cm^4}{D_1^2} + \frac{qcm^4R^2}{D_1^4} \qquad (5)$$

the value of D_1 that gives a minimum I is found from a solution of

$$\frac{dI}{dD_1} = 2\ pc\ D_1 - \frac{2cm^4}{D_1^3} - \frac{4\ qcm^4R^2}{D_1^5} = 0$$

or

$$p\ D_1^6 - m^4D_1^2 - 2\ qm^4R^2 = 0 \qquad (6)$$

An exact solution of Eq (6) presents many difficulties, but a practical solution can be obtained by neglecting the $m^4D_1^2$ term; the approximate value of D_1 from Eq (6) then is

$$D_1 = (2\ qm^4R^2/p)^{1/6} = 1.12\ (qm^4/p)^{1/6}R^{1/3} \qquad (7)$$

An approximate value for D_2 can then be found from

$$D_2 = \frac{mR}{D_1} = \frac{0.893\ m^{1.3}R^{2/3}}{(q/p)^{1/6}} \qquad (8)$$

When the pinions are the same size, and the material and design constants are the same for all gears and pinions, Eqs (7) and (8) reduce to

$$D_1 = 1.12\ R^{1/3} \qquad (7A)$$

$$D_2 = 0.893\ R^{2/3} \qquad (8A)$$

If more than two gear reductions steps are required, the basic equations can be derived in a manner similar to that used in deriving those for the two step system. The equations

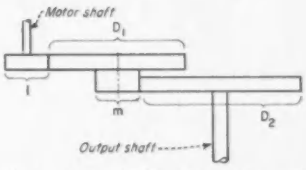


Fig. 5—Gear train showing relations used in finding proportions for a minimum moment of inertia.

obtained will be complicated, however, and their solution tends to give a higher than practical third reduction step. In general, it is sufficient to select the largest usable third step and then with Eqs (7) and (8) compute the first two steps.

In a servomechanism, an increase of backlash in the gear train increases the tendency of the servo to oscillate, while an increase in gear reduction reduces this tendency. The exact effect of these two variables is related to the overall servo system including the design of the amplifier. From a cost consideration, a given servo system requires careful overall design to allow a wide choice in the selection of gear reduction ratios and the permissible amount of backlash.

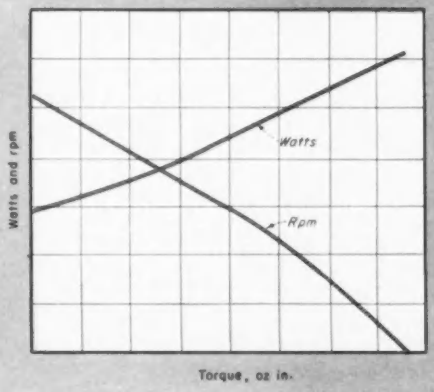


Fig. 3—Torque-speed and power characteristics typical of motors in general use.

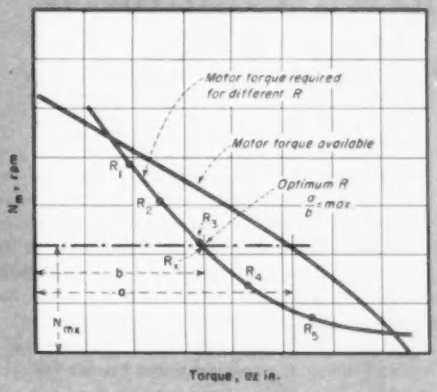
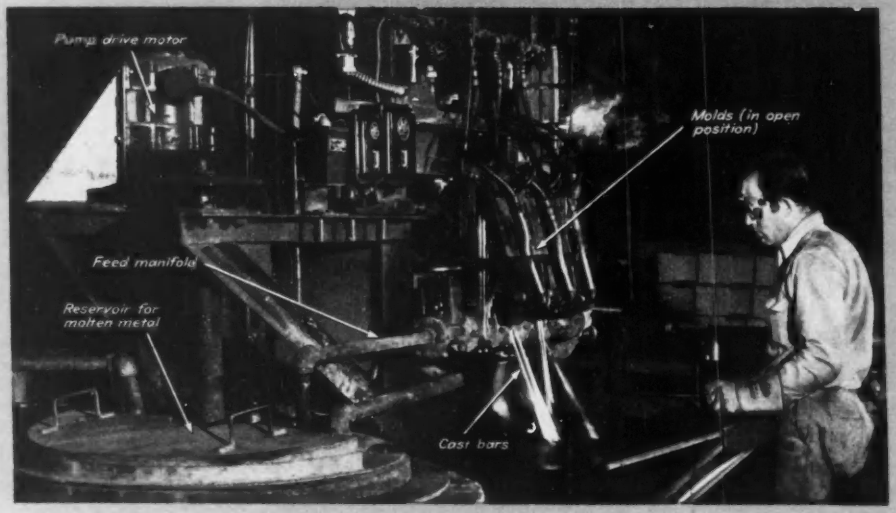


Fig. 4—Graphical method for determining the optimum gear reduction ratio of a step train.

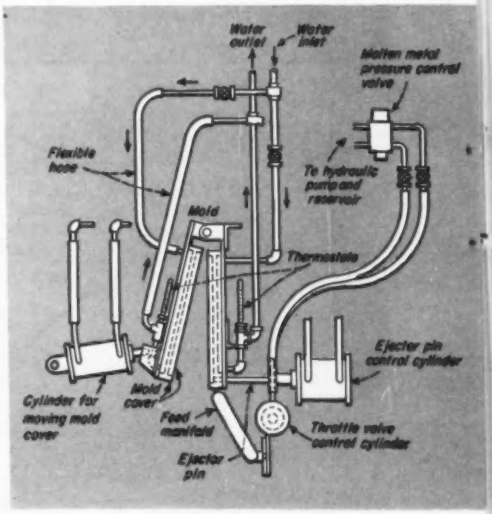


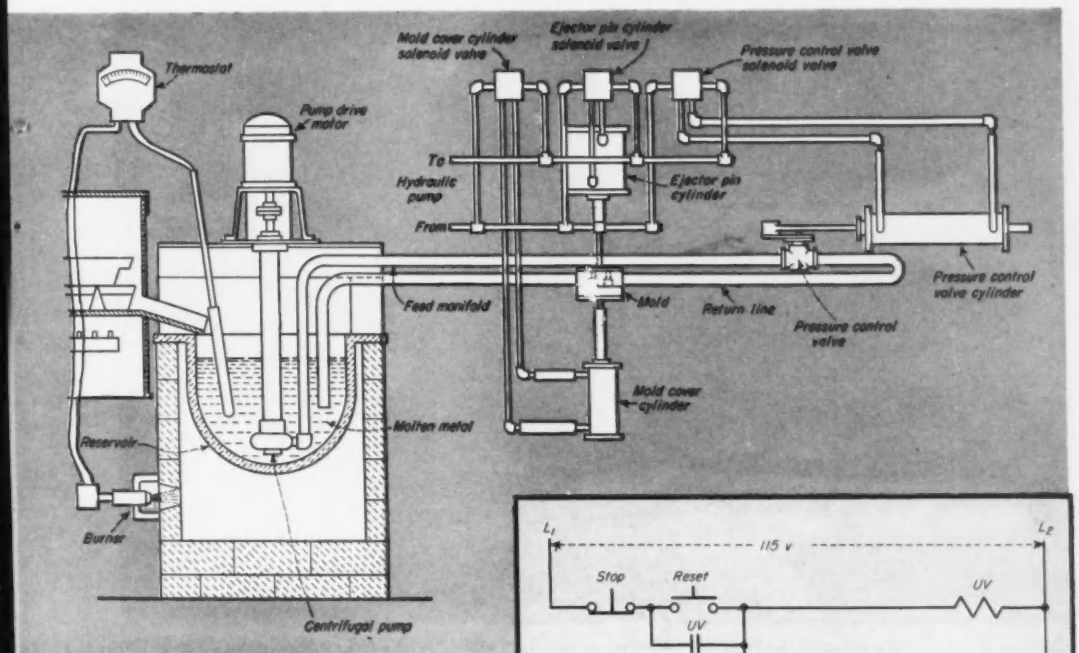
MOLTEN METAL in reservoir at left is fed by a submerged centrifugal pump through the feed manifold to three molds. Cast bars are knocked from the molds by hydraulically-actuated ejector pins. The mold covers are then closed hydraulically.

PRECISE CONTROL of melt temperature, pressure on the metal as it fills the mold, and temperature of the mold cooling water are key factors in the casting process. The centrifugal pump in the reservoir forces molten metal into the molds at a pressure that is low enough to prevent splashing, yet high enough to initiate the filling period rapidly. The remainder of the cycle involves machine elements that are hydraulically actuated. The pressure control valve is closed, building up a back-pressure on the metal for the

Electric Controls For Casting Machine

An electric timing system is the heart of a new casting machine that automatically forms three 1½-lb solder bars every 20 seconds. Four timers energize six relays that cycle solenoid valves in a series of hydraulic circuits. By sequencing the operation of the various hydraulic cylinders, the Castomatic machine fills the molds, which are water-cooled, opens the molds and finally ejects the cast bars. The molten metal circulates in a closed system so that oxidation and contamination are avoided. Through regulation of the pressure and temperature of the molten metal as well as the rate and direction of solidification, bars of uniform structure and appearance, and exact shape and size are produced. Federated Metals Division of the American Smelting and Refining Co. holds U. S. Patent 2,459,892 on the Castomatic (R) machine.



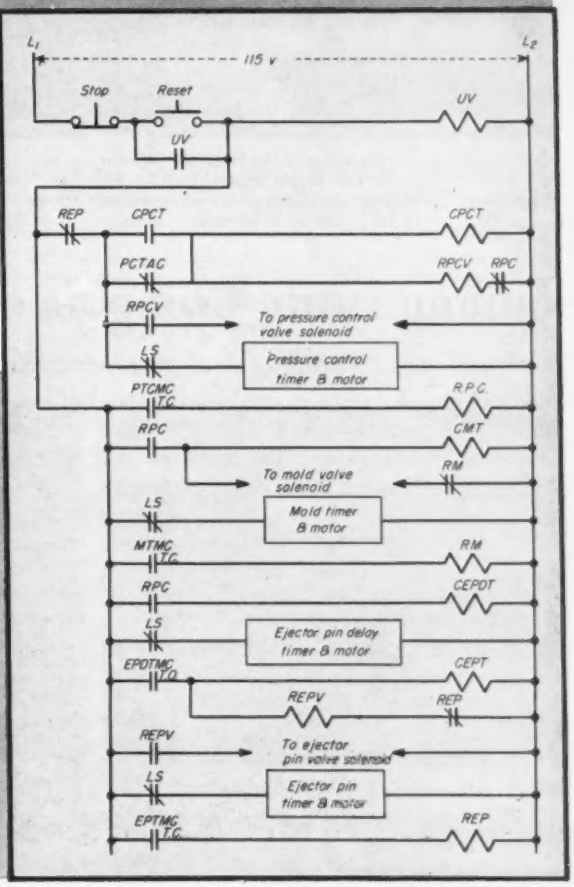


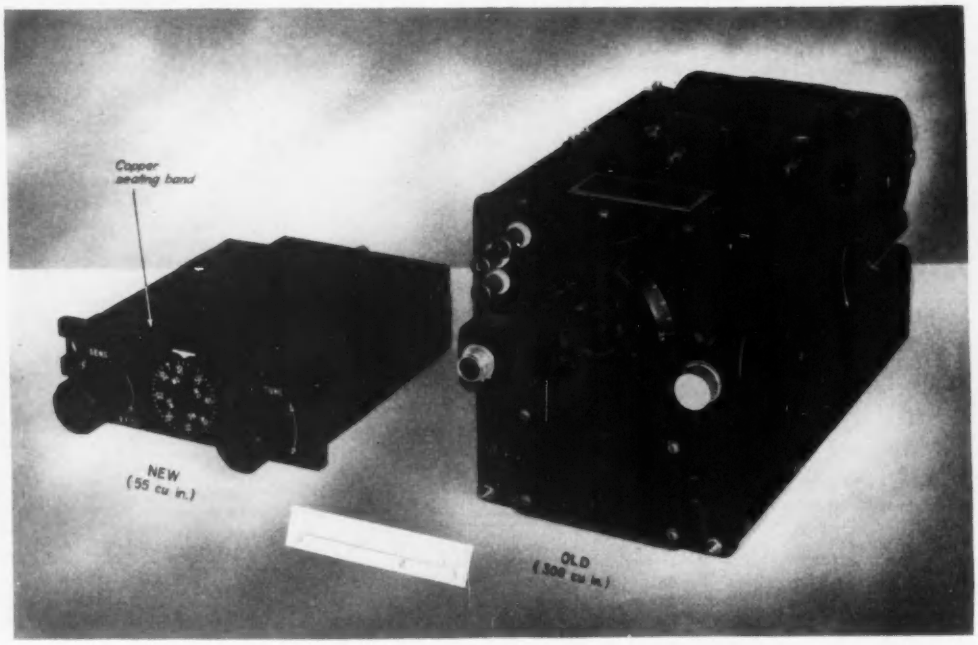
filling period. After the molds are filled the pressure control valve is opened, allowing molten metal to circulate back to the reservoir. The mold cover is then pushed to the open position and the ejector pins extended, knocking the bars out of the molds. Temperature of the metal in the reservoir is regulated by the burner.

DIRECTIONAL COOLING of the metal is achieved by circulating water downward through jackets in the backs of the mold halves. Thermostats control the rate of flow of the cooling water.

ELECTRICAL CONTROL SYSTEM for sequencing the machine elements is made up of four motor-driven timers and six relays. The timer circuits are tied into the pressure control, mold control and ejector pin control solenoid valves in the hydraulic circuit. The ejector pin delay timer is used to allow sufficient time for mold to open and pressure control valve to reopen before the ejector pins move.

L_1-L_2—Incoming control power
UV—Undervoltage relay
REP—Ejector pin relay
CPCT—Clutch coil, pressure control timer
PCTAC—Pressure control timer auxiliary contact
RPCV—Relay press. control valve
RPC—Relay pressure control
LS—Limit switch
PCTMC—Pressure control timer, main contacts
TC—Time closing
CMT—Clutch coil, mold timer
RM—Relay mold
MTMC—Mold timer, main contacts
CEPDT—Clutch coil, ejector pin delay timer
EPDTMC—Ejector pin delay timer, main contacts
TO—Time opening
CEPT—Clutch coil, ejector pin timer
REPV—Relay, ej. pin valve
EPTMC—Ejector pin timer, main contacts

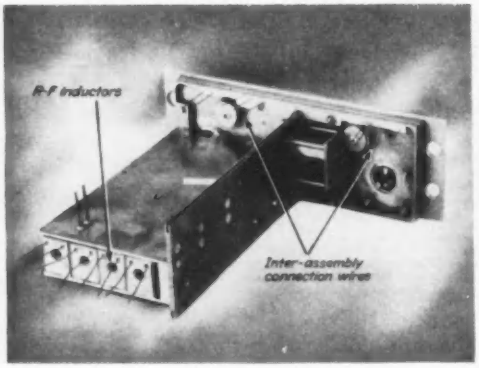




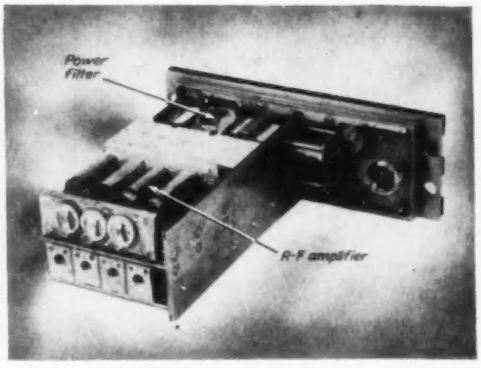
NEW RECEIVER (left) occupies less than one-fifth the space formerly required for the old unit (right). Seven subassemblies are hermetically sealed in an atmosphere of nitrogen by a copper band soldered over the joint between front panel and case. Band is removed with a key of the same type used in opening coffee cans. "Wobbling-bellows" rotary seals for the two control shafts are integral parts of the knobs, thus contributing to compactness of unit.

Subminiature Components Reduce Size of

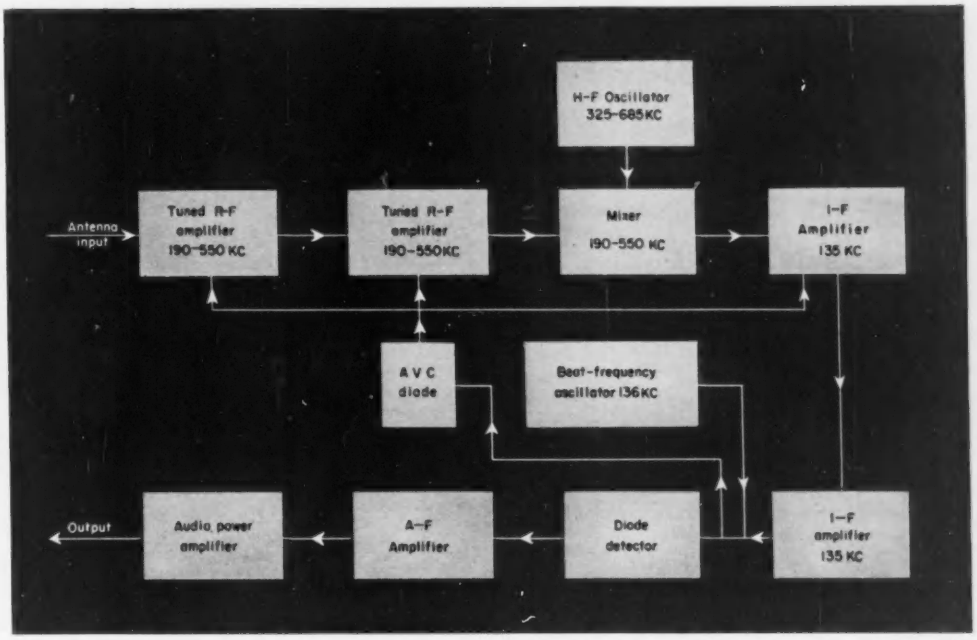
Twelve-tube low-frequency set developed at the National Bureau of Standards has seven



INTER-ASSEMBLY CONNECTIONS are made by soldered projecting wires and small plug-in type connectors. Straight-line tuning is obtained with a variable-pitch screw on the tuning shaft, which drives ferrite tuning slugs in and out of the radio frequency coils.



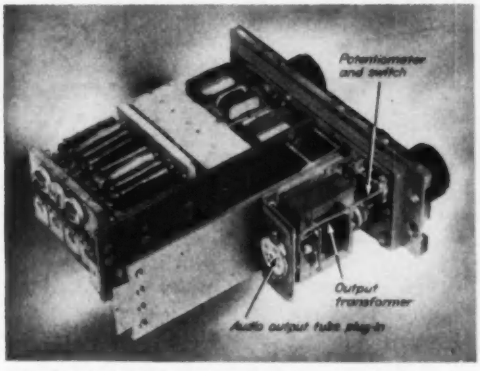
I-F TRANSFORMERS, which measure $\frac{1}{2}$ by $\frac{1}{2}$ by $1\frac{3}{8}$ in. are double tuned and use permeability-tuned indicators of about 2.8 millinhenries and Q of 70 at 135 kc. Resonating capacitors are washer-shaped and mounted in the end of each transformer.



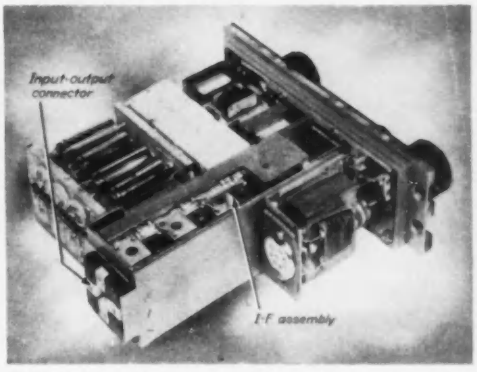
SUPERHETERODYNE CIRCUIT provides continuous tuning from 190 to 550 kc, intermediate frequency of 135 kc, a sensitivity of five microvolts for six decibels signal-to-noise ratio and a power output of 100 milliwatts. Twelve tubes are used in the components shown. The two 135-kilocycle I-F amplifiers have a bandwidth of about two kilocycles and all stages operate with 26 v d-c on heaters, screens and plates.

Radio Receiver by 80 Percent

subassemblies, which are fastened to each other and to a $5\frac{3}{4}$ by $1\frac{7}{8}$ in. front panel



AUDIO OUTPUT TUBES plug into a set-back outside the case. Gain control has a high-temperature tape resistor bonded to a small glass cylinder, which carries 120 axial lines of silver paint. These commutator segments are engaged by a precious-metal brush.

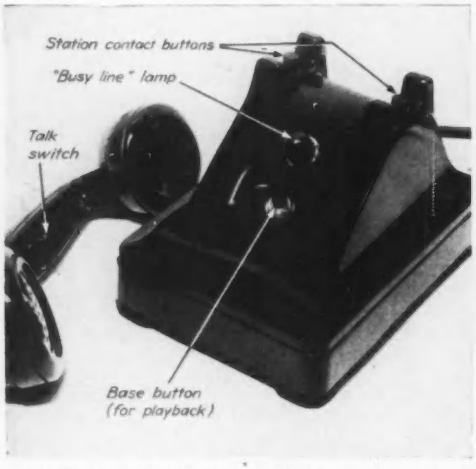


POWER FILTER and r-f amplifier, like the other subassemblies in the receiver, have conductors that are "printed" on steatite and silicone-impregnated glass fiber insulators. Entire receiver is designed to make field servicing by non-technical personnel a simple procedure.

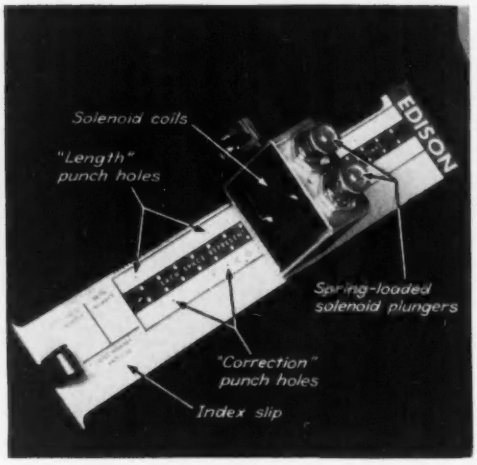
Multi-Station Dictating System

Thomas A. Edison, Inc. of W. Orange, N. J. have modified their Voicewriter dictating machine (Product Engineering, May 1949) for remote operation from as many as 20 separate stations. In this Televoice system, two pairs of twisted wires couple telephone-type station instruments to a central recorder. Each station, whether desk or wall mounted, has a press-to-talk button in the handset, a red "busy" light and a base button. These are part of a visual and audible electronic signal system that enables the dictator to play back a recording and make corrections, and warns both recorder operator and dictator when the disk is approaching the "full" point, necessitating a change.

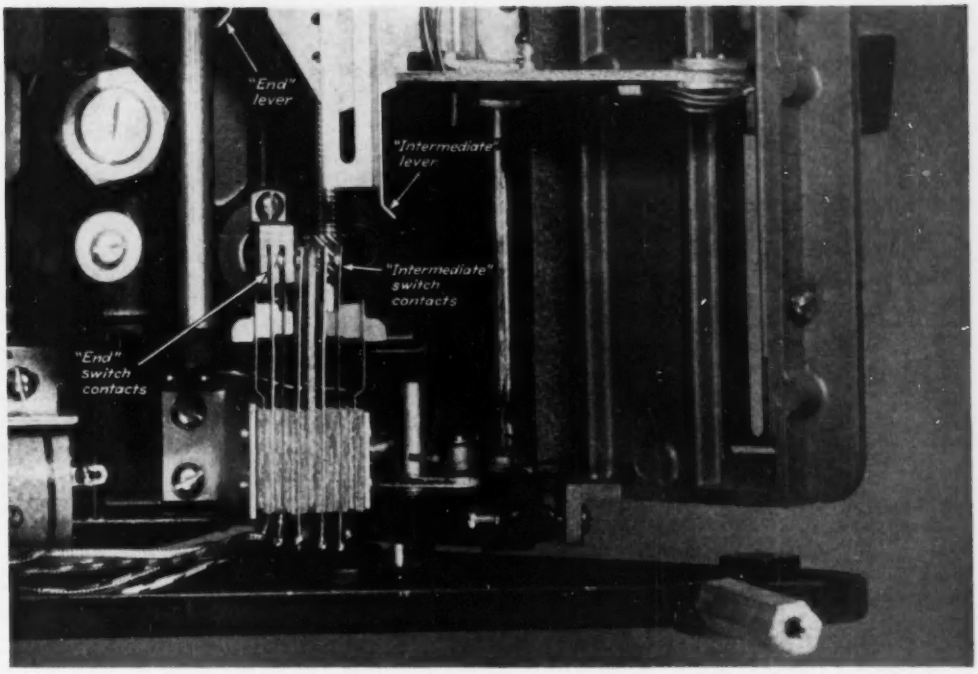
MODIFIED RECORDER has solenoid-operated instead of finger-actuated punches on front carriage and two signal lamps—one to show when line is busy and the other to flash if the machine is not fully prepared for use. A buzzer notifies the secretary when a new disk must be installed.



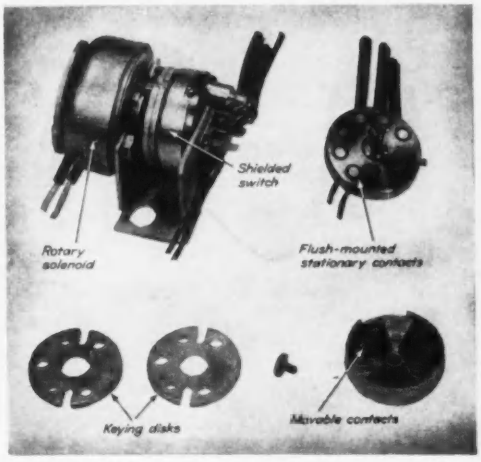
STANDARD TELEPHONE RECEIVER is the only system component handled by the dictator. Pressing the handset button starts the disk by actuating a clutch in the recorder, whereas the base button plays back the last fifteen to twenty recorded words. Simultaneous operation of both buttons causes a solenoid to punch a hole in index slip.



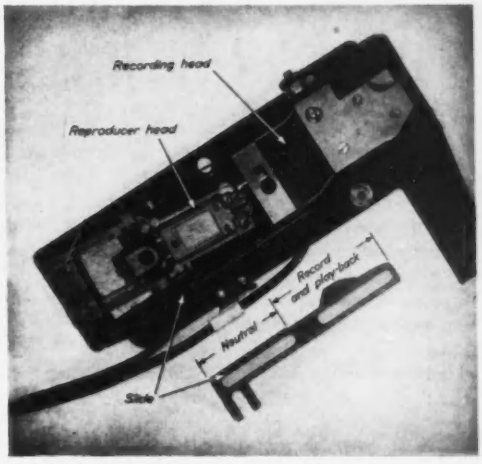
CORRECTION and length markers travel 5½-in. length of index slip in synchronization with 1½-in. movement of recording arm across the face of the disk. When either a correction is made or a batch of dictation completed, signals from a station energize the solenoids by momentarily discharging a capacitor through the coils.



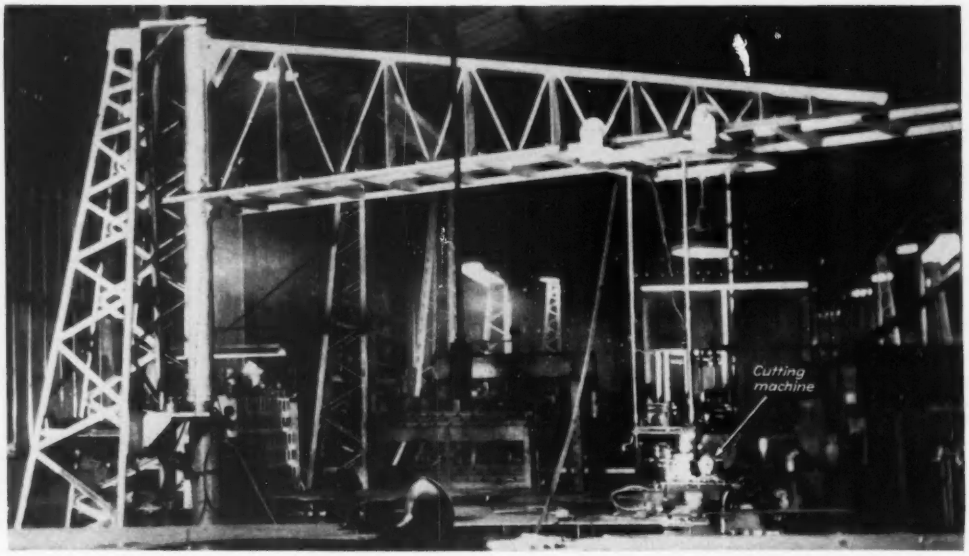
"INTERMEDIATE" and "end" switches for signalling the approach and finish of a disk by producing ticking sounds in the station instrument are actuated by two independently adjustable levers mounted on the carriage. Resembling in many ways the telephone-type relay, the combination switch assembly is mounted directly on the top chassis plate. "End" switch is single-pole double throw, the time interval between opening and closing determining the tick duration.



TWO-POLE SHIELDED SWITCH changes system from "record" to "reproduce". Rotary solenoid actuator is operated by a capacitor discharge plus a resistive holding circuit when the station base button is depressed. Coil spring returns switch to "record" position when button is released. Arrangement of contacts prevents flash-over.



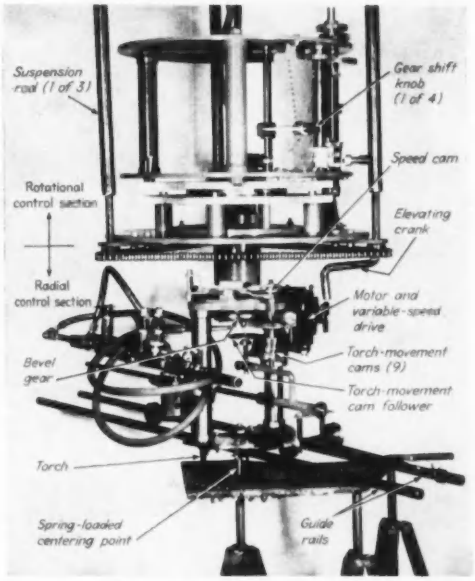
SLOTTED SLIDE has been modified to locate recording and reproducing heads in two operational positions—"record" and "neutral". In "record", both heads are on the disk, the reproducer being offset to trail the recorder by about three grooves; in "neutral", both are raised. Rollers attached to the heads ride on top edge of the slide.



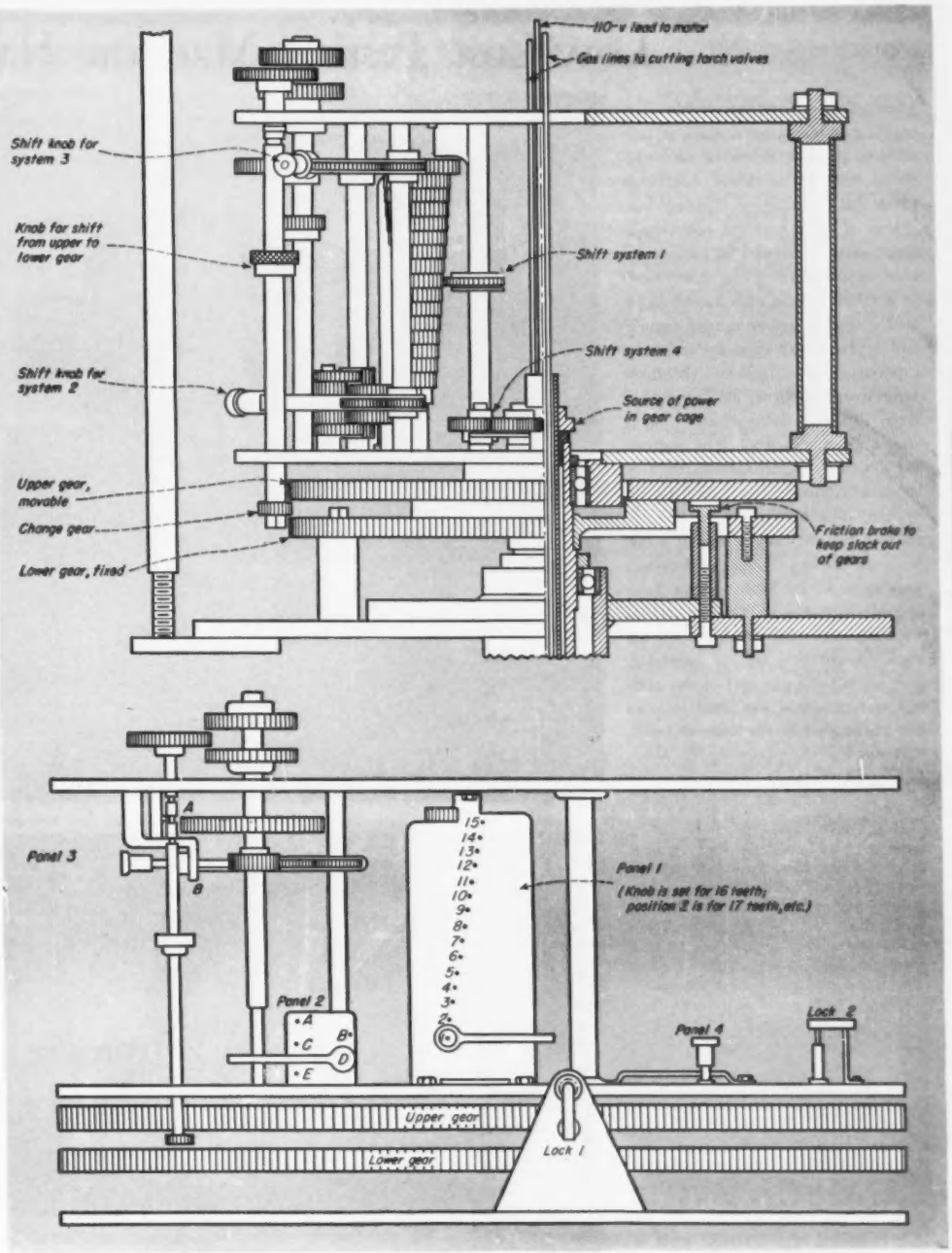
CUTTER ASSEMBLY hangs from a traveler that rolls along guide rails extending the length of the 20-ft boom. Latter can be swung in a semi-circle around the 12-ft mast. Steel sheets are supported on jacks at a level just below the centering point on the bottom of the cutter assembly. A torch is then guided above the sheet as teeth are cut.

No Master Pattern Used in Sprocket Cutter

Sprocket wheels having diameters from three inches to five feet and as many as 361 teeth can be cut from sheet steel up to 6 in. thick with the Schrock cutter. Six minutes are required to cut a 25-tooth sprocket of one-foot diameter from $\frac{3}{4}$-in. sheet. The machine is not of the tracer type because no master pattern is required. Five gear shift systems and ten cams determine the rotational speed of the entire cutting unit and radial movement of an oxy-acetylene cutting torch mounted on a carriage. The assembly is suspended from an overhead crane and positioned by a centering point that rests in a hole punched in the surface of the steel sheet. Power for the 1/20 hp drive motor and gas for the torch are delivered through cables and hose that hang from the crane. Accuracy of the 1/8-in. cut is such that only the sides of the plate adjacent to the teeth must be machined to establish the proper face width of the teeth. Manufacturer is the Idaho Sprocket & Machine Works of Boise, Idaho.



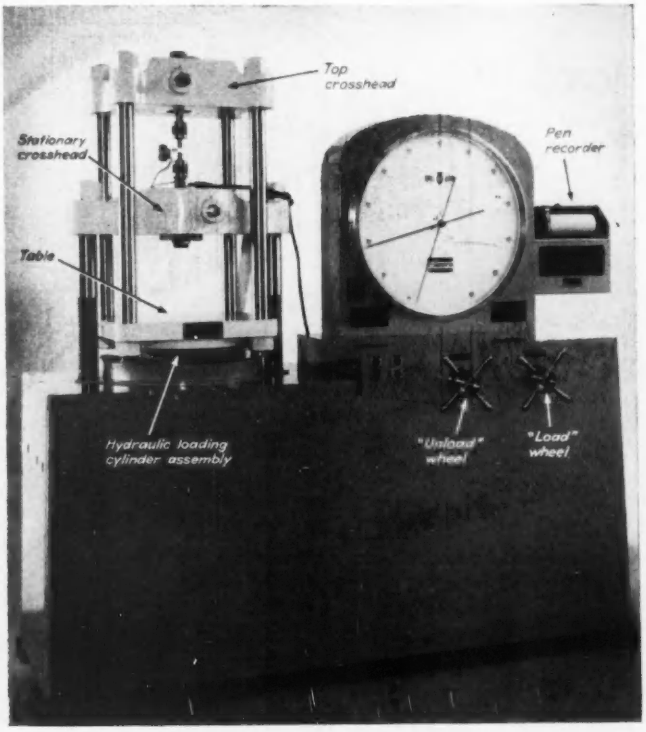
MOTOR ROTATES upper gear system through variable-speed drive and bevel gear. Speed cam and cluster of nine torch-movement cams are driven directly from the motor. As the speed cam rotates, it moves the control arm of the variable speed drive, thus controlling the rotation of the machine. To obtain a given radial movement of the torch, the cam follower is lined up with the proper cam.



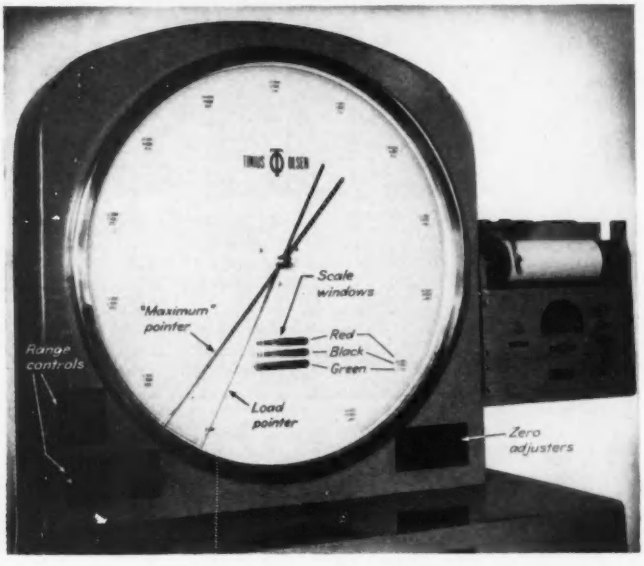
NUMBER OF SPROCKET TEETH is determined by adjustment of the five gear systems. Setting on panel 1 is the basis for positioning the other panels. With panel 2 on A, ratio on panel 1 is quadrupled; on B, it is doubled; on C there is no change; on D, it is halved; and on E, it is quartered. Panel 3 divides by three when in A position. Panel 4 reverses the direction of the machine's rotation. In upper gear, panel 5 adds a tooth by differential gearing when machine and central shaft have opposite rotation; and subtracts a tooth when their rotation is same.

Low-Cost Testing Machine Has

Unitized and interchangeable electronic assemblies have made it possible to produce a line of new universal testing machines that cost about half as much as standard machines of the same type and capacities. These Super "L" machines have capacities ranging from 1,200 to 400,000 lb and each model has a 50-1 spread of testing ranges, namely full capacity, 1/5 capacity and 1/50 capacity. Zero loads for the three ranges are the same, all being read from different colored scales on a single 28-in. dia dial. The indicating system is electronic and entirely separate from the hydraulic loading system, thus making it possible to change the test ranges during a test without altering the rate of loading. Engineers at the Tinius Olsen Testing Machine Co. of Willow Grove, Pa. have also made provision for the rapid installation of an automatic pen recorder at one end of the cabinet and different size load cells in the loading arbor, the latter to facilitate testing of specimens in ultra-low ranges to high accuracy.

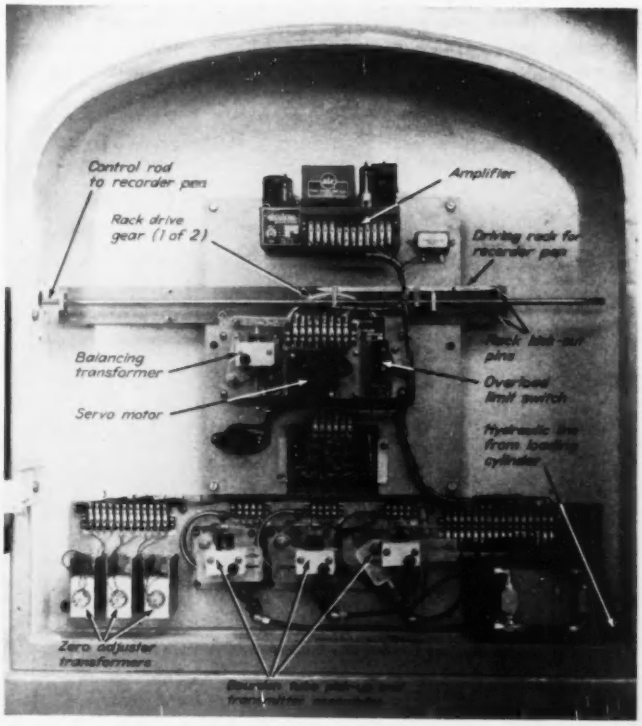


(Above) Hydraulic loading cylinder assembly has low center of gravity, thus obviating need for rollers and guides, and reducing shock when test specimens break. Testing speeds are infinitely variable up to 2 in. per min from the "load" and "unload" control wheels at right end of base cabinet.



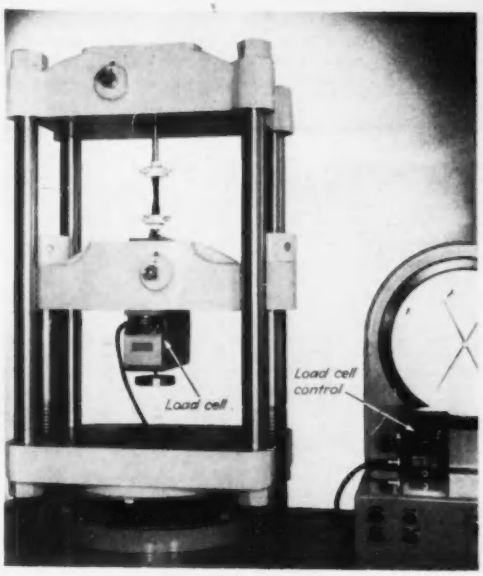
(Below) Graduated scale divisions on the 28-in. dia dial are spread over a 307 deg arc so that standard drive gears can be used in the recorder pen drive mechanism inside the cabinet. For ease and accuracy in taking readings, each set of scale numbers is identified by a different color. The "high" scale is in red, the "middle" scale is in black and the "low" scale is in green. This feature is also used in the "windows" in which the scale range limit and number of pounds per division appear with the appropriate color as a background.

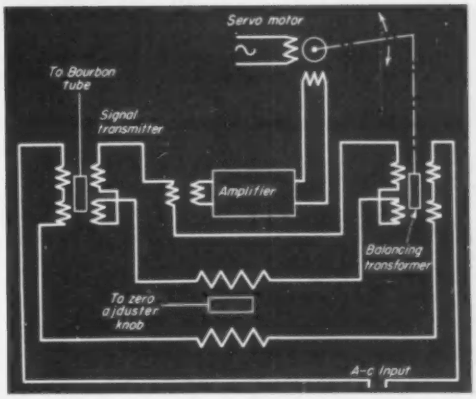
Electronic Indicating System



(Left) Electronic indicating system consists of two panel assemblies, each of which has interchangeable subassemblies. Hydraulic pressure from the loading cylinder actuates one of the Bourdon tubes which displaces the core in its differential-type transmitter. The signal generated is then amplified and feed to the servo motor which turns the dial pointer. Recorder pen drive assembly is attached with two machine screws. Rod has knob at recorder end. By turning the recorder pen control rod 180 deg, rack engages the large gear shown or a smaller concentric gear (not shown), thus providing either a 2:1 or 1:1 ratio between pen and dial pointer.

(Below) Null balance circuit controls movement of the dial pointer. Output from Bourdon tube signal transmitter is 180 deg out of phase with that of balancing transformer. The voltage difference is fed through the amplifier to one phase of the two-phase servo motor. Other phase of the motor is energized continuously. When the transformers have equal out-of-phase voltages, the motor is at rest. As soon as the Bourdon tube moves the transmitter core, a restoring signal is produced which causes the motor to bring system into balance.

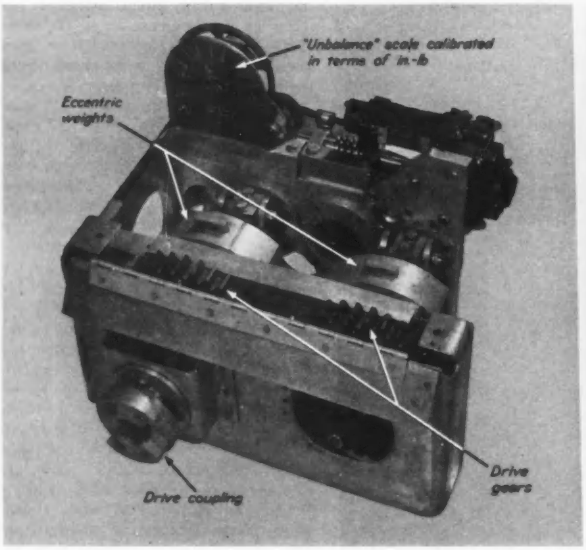




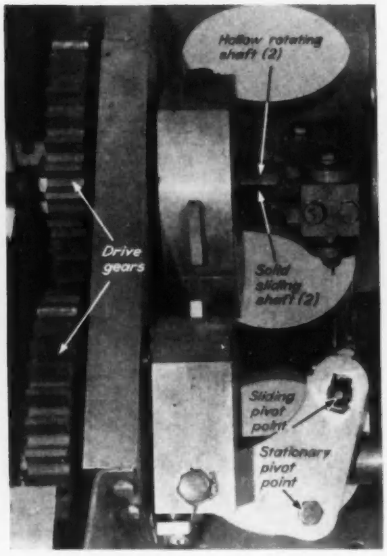
(Left) For conducting tests in the very low ranges, provision is made for rapid attachment of different size load cells to the crossheads. Plug-in connections on the side of the cabinet are provided for the load cell control cables. The many standard and specialized tools for testing different materials such as cast iron, cement, asphalt plaster wood and refractories are easily located on the crossheads.

Mechanical Vibrator Adjusts

The mechanical vibration exciter shown is being used at the Glenn L. Martin Company, Baltimore for investigating the vibratory characteristics of aircraft components. Two counter-rotating horseshoe weights move toward and away from their axes of rotation which will vary the force



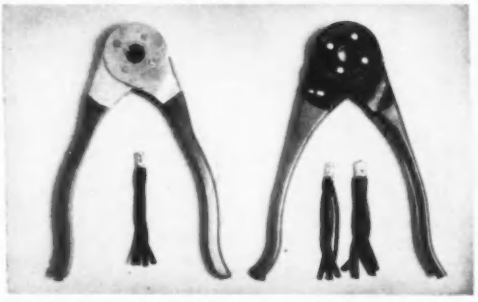
UNBALANCED FORCE is produced by a matched pair of eccentric weights, gear driven at equal speeds. Each weight exerts a centrifugal force at its center of gravity that acts normal to its axis of rotation. If the two weights have no relative angular displacement, the resultant force exerted by the vibrator is vertical and varies sinusoidally as the weights rotate. All horizontal components of the force are cancelled because the gears rotate the weights in opposite directions. Maximum value of output force equals the sum of the individual unbalances.



THE TWO DRIVE GEARS are mounted on the hollow shafts that are fastened to right-angle bell cranks at the stationary pivot points. The cranks are free to pivot about these points in a plane parallel to the shaft axes, but are constrained to rotate with the hollow shafts. Sliding pivot points of the bell cranks are connected to the sliding shafts located within

Redesign Extends Tool Capacity

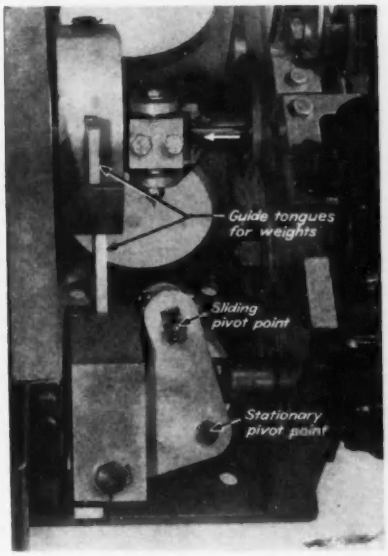
The hand crimping tool is an essential part of the Buchanan system of making solderless connections. Stripped ends of the wires to be joined are placed in copper splice caps in the tool and crimped into place, resulting in connections that are secure both electrically and mechanically. The tool was recently redesigned to permit its use on both large and small splice caps. In addition, the redesign has cut its cost appreciably and reduced effort needed for operation.



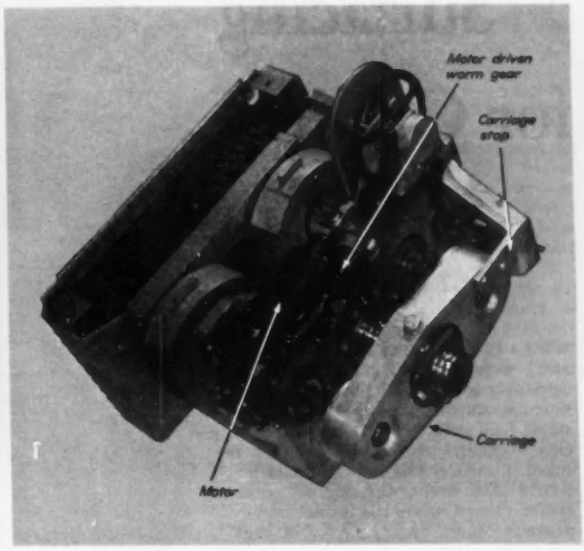
NEW CRIMPING TOOL can be used on both large and small sizes of solderless splicing caps because redesigned cam surfaces provide greater travel of the crimping plungers. The former version (left) of the device was suitable for one size of splice cap only.

Output Force While Running

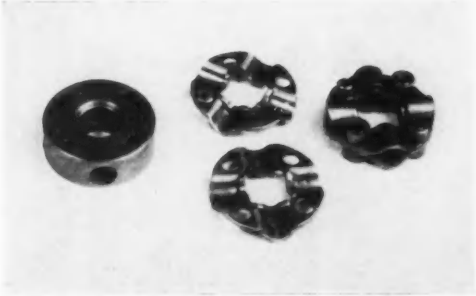
while they are in motion. The output force can be changed without stopping the machine and any pre-set value of force can be held automatically over the entire speed range by an electronically controlled servo system. The direction of the output force can also be adjusted to any desired angle.



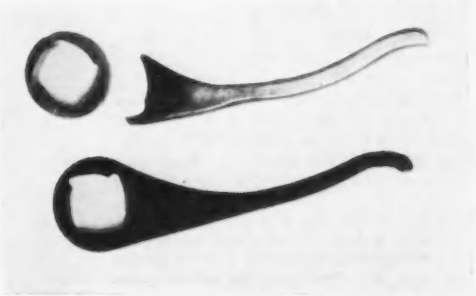
the hollow shafts. (Above) The unbalance has been reduced by moving the sliding shafts and thus the sliding pivot points in the direction shown. The rectangular tongues projecting through the weights are integral with the hollow shafts and limit the movement of the weights to a plane perpendicular to the axes of the shafts. Crank ends move in arcs.



AXIAL POSITION of the sliding shafts which is controlled through a suitable motor gear drive determines the value of the output force for any one setting of the rotating speed by controlling the eccentricity of the weights through the crank systems. By introducing appropriate values of relative angular displacement between the two weights, the direction of the output force can be adjusted through the range from vertical to horizontal. Variations in the speed of the main drive system will affect the value of the output force.



PLUNGER BODY of old tool (left) was machined from bar stock in eight operations. Cost of this was reduced about 50 percent by going to the construction shown at the right. The plunger body now consists of two coined sections, held together by bushings and spacers.



CAM HANDLE of previous design was made by brazing machined cam ring to the stamped handle. New handle is one-piece forging in which cam surfaces are machined. Forged part is stronger, costs less than brazed handle. Buchanan Electrical Products Corp., Hillside, N. J.

Metal Surfacing for Original Parts

WITH A PROPER CHOICE OF MATERIAL many metal surfacing applications result in an outer layer and part being more durable and wear-resistant than the base metal. For example, hard surfacing of rolling mill guides, cement grinders, and oil-well drills, has resulted in surfaces that are superior to heat-treated alloy steels; surfacing of gasoline engine exhaust valves has become standard practice.

In the case of metallizing, many unusual applications have developed; these range from protecting steel structures from atmospheric corrosion to the spraying of printed electrical circuits on plastic bases. Shafts built up with sprayed metal have shown excellent bearing qualities due to the porous nature of this material.

The very thin coatings from the high vacuum process have opened new fields. Current metal shortages have been an important factor.

Welding

The problem may be one of sliding metal-to-metal contact, rolling contact, heavy shock or impact, corrosive action, or high-temperature operation. Although hardness is usually directly related to the resistance of abrasive wear, the structure of the surfacing material is also significant. Based on a series of laboratory tests, a comparison of

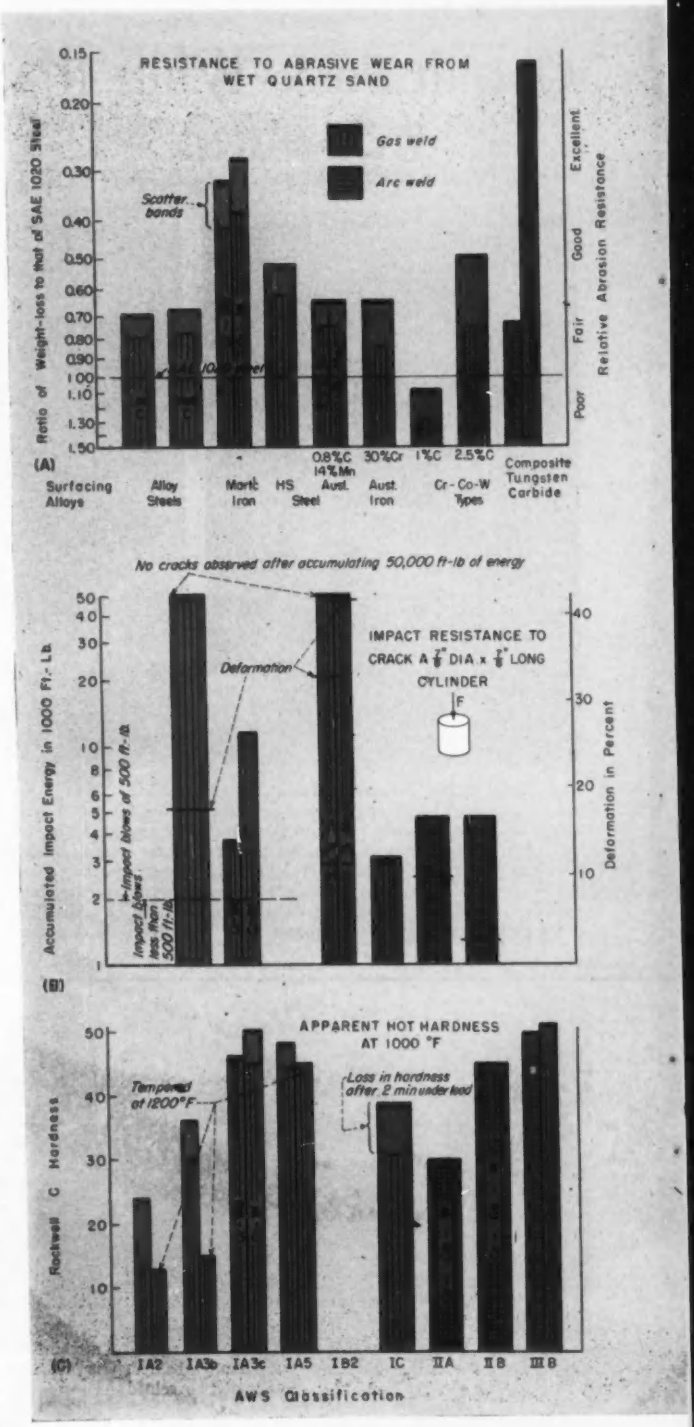


Fig. 1—Selecting a proper surfacing material is dependent on service conditions of the particular application. (A) For abrasive wear this chart shows the relative values of common types of facing materials. (B) In applications of shock loads, the facing materials chosen should possess energy absorbing qualities without fracture. (C) Another factor to consider is that of strength at elevated temperatures.

American Brake Shoe Co.

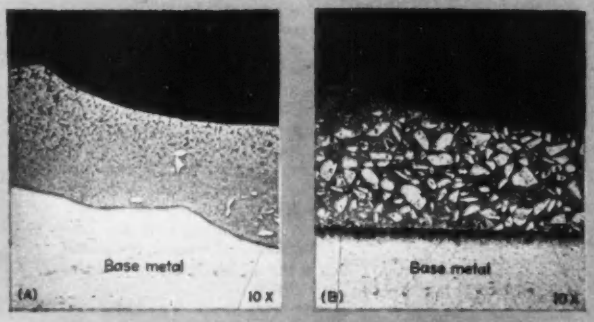


Fig. 2.—Type of weld used in applying composite tungsten carbide affects its wear resistance. (A) Higher temperature of arc weld dissolves carbide particles in matrix. (B) Gas weld retains more solid particles which possess good wear qualities.

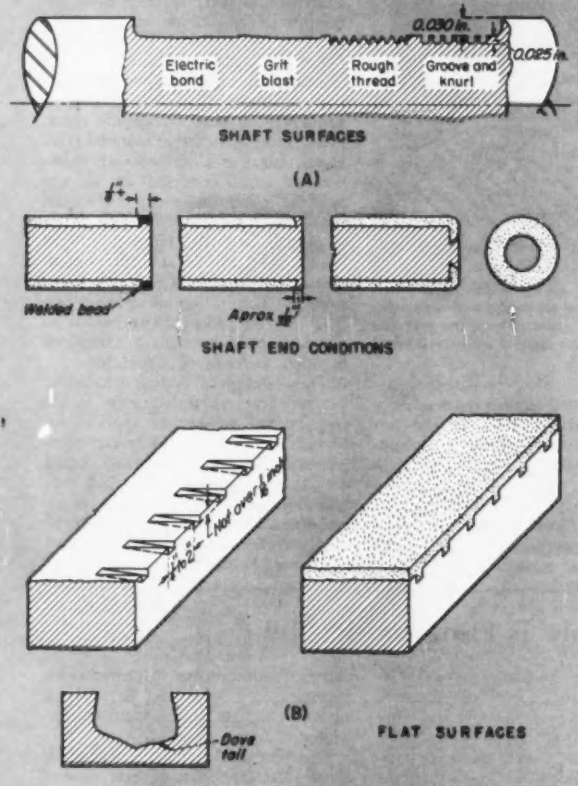


Fig. 3.—Optimum bond strength of the metallized coating requires surface preparation of the base metal. (A) four common surface conditions used on shafts. (B) Slotting and dovetailing insure a good metallizing attachment to flat surfaces.

the abrasion resistance of several surfacing materials in contact with wet quartz sand is shown in Fig. 1(A). In addition, another graph (Fig. 1(B) illustrates the relative impact resistance of these materials. Note that two materials did not crack after absorbing a total of 50,000 ft lb of energy. The apparent hot hardness of surfacing materials is shown in Fig. 1(C) where the creep or loss in hardness after an interval of 2 min is illustrated. With such data, the problem of choosing a surfacing material is simplified to that of understanding the service conditions.

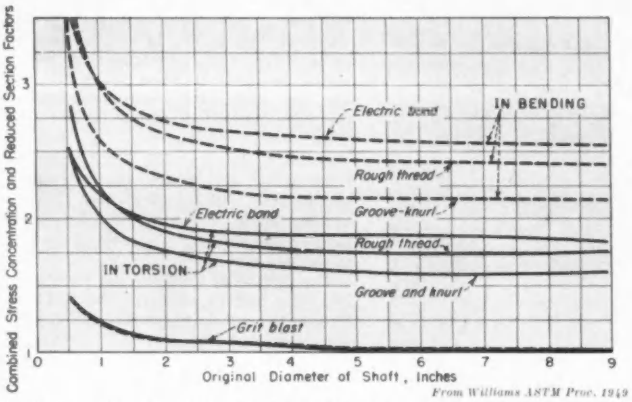
The method of welding (gas or arc) can affect the final properties of the surfacing. Most of the data in Fig. 1 is based on materials which were gas welded. In one instance there is a very wide difference in the wear resistance due to the method of surfacing. This is shown in Fig. 1(A) for the composite tungsten carbide (fine-granule) material. Here, the particles of tungsten carbide are contained in a hollow welding rod; with the high temperature of the electric weld, most of the particles become dissolved in the matrix. This is shown in Fig. 2. Gas welding having a less intense heat does not dissolve but retains most of the particles which possess outstanding wear resistance.

Metallizing

Spraying finely divided particles of molten metal is another method used to surface metals as well as non-metallic materials. The most common method utilizes a gun through which wire is fed into an oxy-fuel gas flame and a blast of high velocity air which projects the small particles of metal against the surface to be coated. The mechanism of attachment is not fully understood for the particles are no longer molten when they reach the surface to be coated. The bond is basically one of mechanical interlock with a small amount of welding and some oxide cementation between particles.

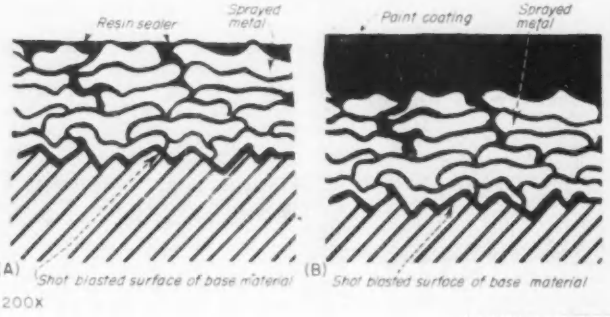
Although the metallized material chemically resembles that of the base material, the physical properties are quite different. The structure is not homogeneous, and bears a resemblance to that of certain sintered metals. The tensile strength of these coatings is quite high, but the ductility is low, and all coatings are porous to some extent. To insure a satisfactory bond between the base metal, a certain amount of surface preparation is necessary. Recommended procedures are illustrated in Fig. 3. Of the four types shown in Fig. 3(A), grit blasting is preferred since the stress concentration effect is less severe. The graph in Fig. 4 includes the effects due to either bending or torsional stresses and also accounts for the reduced shaft diameter.

One of the greatest uses of metallizing is in the salvaging operation of extremely worn or mis-machined parts. For this purpose there is available a wide selection of metals and alloys. These coatings can be applied without overheating and distortion of the



From Williams ASTM Proc. 1949

Fig. 4—Type of surface preparation increases the stress concentration effect in shafts subjected to bending and torsion. Grit blasting shows the least detrimental effect.



Metallizing Engineering Co.

Fig. 5—Aluminum or zinc metallized surfaces are effective corrosion resistance coatings. **(A)** For under-water and corrosive media, resinous sealer reduces the exposure of metallized surface and prolongs life of coating. **(B)** Paint applied to sprayed metal makes a more effective base to which the paint can cling.

base metal. More recently metallizing has been used for corrosion-resistant purposes where either zinc and aluminum are applied. These coatings are frequently used for protection against atmospheric corrosion, and although porous in nature, they are occasionally used for coating metals which may be immersed in salt water. Under these conditions the iron or steel will not corrode as long as any metallic zinc remains on the surface. By using special synthetic resins to seal the pores of metallized surfaces, the corrosive media is prevented from penetrating this coating. As shown in Fig. 5 a metallized surface is often used as a base to which paint can be applied. Such composite coatings have proven to last much longer.

A recent development of metallizing is in hermetically-sealed glass-to-metal joints. By spraying the contacting surfaces of the glass with copper, the joint is later attached to metal and sealed by means of solder. Tests have shown that shafts metallized in the bearing region continued to operate for short periods after the oil supply had failed. This is estimated to be the result of the contained lubricant in porous metallized material as well as its lower modulus of elasticity.

In applications of expendable devices and missiles, aluminum oxide coatings on steel have proven satisfactory for high-temperature operation but only for short periods.

Vacuum Coatings

Developments in the high vacuum field have recently made possible the commercial application of evaporated metallic coatings to plastics, wood, paper and metals. Brilliant, lustrous finishes are obtained by this technique and include aluminum, copper, gold, Inconel metal, nickel and silver. Metallic particles are evaporated from heated metal in a high vacuum chamber and which condenses on all surfaces in direct line from the source.

Coatings can be built up with dimensional precision ranging upward from a millionth of an inch. Consequently, the surfaces are extremely smooth. The fusion of minute particles in this process often results in a greater bond strength as compared to other methods of deposition.

The shortage of critical metals and the economy of this process is increasing the number of applications. Several refrigerators have freezer compartment doors of plastic and coated with evaporated aluminum. This cuts heat losses and also saves metal. Automobile radio speaker grilles made of metallized Seran gives a grille that does not rattle like metal.

Scrap Steel Supply Is Dangerously Low

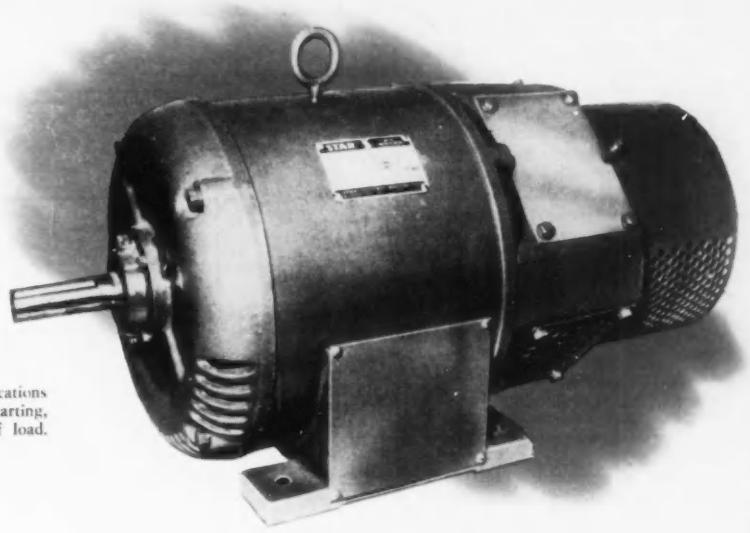
STEEL PLANT INVENTORIES of iron and steel scrap are fluctuating between days and a few weeks, a dangerously low level as compared with a normal 60-day supply.

Under the press of an emergency, the length of which no one can foretell, the steel industry is to supply steel for military uses, defense-related products, and consumer items. This can be done only if furnaces are not idle because of a scrap shortage.

Rebuilding inventories of scrap requires the assistance of administrative officials in business, industry and other fields. Large tonnages of scrap can be found in plants and on industrial, commercial and civic sites. This scrap must be declared obsolete, sold as scrap, and moved back to steelmaking furnaces.

How long the current emergency will last cannot be predicted. Current inventories must not only maintain current production but it must also be increased to a safe level to avoid a similar scrap shortage situation this winter.

This year, steel companies will need about 32,500,000 tons of scrap—some 3,500,000 tons more than last year's record tonnage. Next year they will need over 35,500,000 tons. These additional tonnages do not have to be manufactured—they need only to be found.



D-c brakemotor for applications requiring frequent starting, stopping and braking of load.

Choice of D-C Motors

Most new d-c motor applications are in a-c locations. Users are willing to pay the premium for conversion to get the benefits of d-c motor performance. But the customer still wants his money's worth, so the economic factor is involved in the selection.

JOSEPH WINSTON
Design Engineer
Star Kimble Motor Division

THE CHOICE OF THE PROPER TYPE of d-c motor for a given application is usually based on its adjustable speed characteristics. These characteristics may best be explained by reference to the following equation:

$$\text{Motor } RPM = \frac{K\,(V - I_a R_a - v)}{\phi} \quad \ldots\ldots (1)$$

where K = a constant depending on the armature winding
V = the applied voltage
I_a = the armature current
R_a = the armature circuit resistance
ϕ = the flux per pole
v = the brush contact drop, which varies from 0.5 to 2.5 volts, depending on the brush grade used.

When the armature current of a plain-shunt motor operated from a constant voltage rises with load, the armature becomes an electromagnet with poles fixed in space between the stationary main poles. The magnetic field set up by the armature poles is superimposed on the main field in such a way as to strengthen the main-pole flux under one pole tip and weaken it under the other. When the armature teeth and pole face saturate, the net flux is usually decreased more under one-half of the pole than it is increased under the other half. The result is a net decrease in ϕ under load, tending to make the speed rise. An increased I_aR_a drop, however, tends to decrease the speed with increase in load. Since the brush contact drop remains approximately constant over a wide range of loads, the increased I_aR_a and decreased ϕ tend to offset one another to the extent that the speed remains fairly constant. In certain highly saturated short time rated d-c motors the armature reaction may not have any noticeable effect on the main field flux at normal voltage.

A study of Eq (1) will reveal that the speed of a d-c motor may be adjusted by changing the terminal voltage, the armature circuit resistance, or the main field flux. If the speed of the less costly induction motor were varied by changing the terminal voltage, its maximum torque and continuous permissible torque output would be greatly reduced. The torque of an induction motor at any speed is proportional to the square of its applied voltage; whereas a d-c motor may be used to drive a constant torque load while its terminal voltage is varied over a wide range.

A plain shunt motor becomes unstable if it has a rising speed-load curve. This type of curve is obtained when the effect of armature reaction is greater in decreasing ϕ in Eq (1) than is the effect of increased I_aR_a in decreasing the numerator of the fraction. If a shunt motor has a rising speed-load curve, an increase in load on its shaft will cause it to run faster, increasing its losses and the

horsepower required by the load. This makes more current flow from the line. The effect is cumulative because the increased current causes higher speed and further increased load and losses until the circuit breaker opens or the motor destroys itself.

The effect on ϕ of demagnetization due to armature reaction is in general greater percentagewise at reduced excitations and overloads. Furthermore it is assumed that most d-c shunt motors might at some time have their speed adjusted by field control. For these reasons it is usual in integral horsepower sizes for stabilized-shunt motors to be supplied for applications where speed is either to be constant or adjustable by field control. Such motors have light series fields to insure a stable drooping speed-load curve, especially when operating with a weakened shunt field.

Even when operated at full field, some large plain-shunt motors which were stable when cold have started to "run away" when hot owing to the weakening of the shunt field. The increase in the field resistance is caused by the rising temperature as the motor became hot.

For loads such as constant-speed conveyors, pumps, fans, blowers, wood-working machines, motor-generator sets, line shafting, compressors, power-plant auxiliaries, grinders, concrete mixers, laundry machinery and textile mill looms, speed variations with change in load amounting to as much as 15 percent of the full-load speed are generally permissible. In such applications, the changing load is brought about mainly by changing torque requirements. The stabilized-shunt motor is well suited as a constant-speed drive because of its relatively low speed regulation and good stability under overload conditions.

Plain Shunt Motors

Plain shunt d-c motors are usually used in conjunction with generators having drooping voltage-current curves. In such cases they are part of adjustable voltage drives and operate stably with relatively good speed regulation and may be simply reversed by reversing the main generator polarity. There is no costly reversing contactor required to reverse a series field on reversing armature polarity as there would be with a stabilized-shunt motor. Excellent speed regulation may be obtained, even at greatly reduced terminal voltages, by building the main generator with a light series field.

Speed control of plain shunt motors by inserting an adjustable resistance in the field circuit is usually not recommended unless the machine is part of an adjustable-voltage drive. Plain-shunt, integral-horsepower d-c motors operated from fixed voltage sources cannot usually be field weakened by more than a small amount without instability being encountered. Standard stabilized shunt motors, often referred to merely as "shunt" motors, however may be field weakened over a 2:1 speed range where mechanical and commutation difficulties do not dictate the advisability of smaller speed ranges.

Where wider speed ranges are required than are permissible with standard motors, "adjustable-speed" d-c motors may be supplied. Usually these motors are designed for 3:1 or 4:1 speed ranges by field weakening. They are stabilized-shunt wound and are furnished with large air gaps to minimize distortion of the main field by armature reaction. Also, these special motors are designed to have low bar-to-bar voltages to insure the best possible commutation at the top speed, adequate ventilation to prevent overheating at the low end of the speed range, and sufficient mechanical strength to withstand the increased stresses which exist in the rotating members at the high end of the speed range. Adjustable-speed motors are in general more costly to manufacture, engineer, and test. Therefore, the prices of such motors run much higher than those of standard motors.

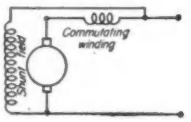
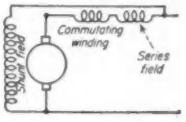
Adjustable-speed d-c motors should preferably be applied on 115 or 230 volts. The use of higher-voltage motors makes it more difficult to obtain good commutation at weak field and therefore limits the range of field weakening obtainable with a given horsepower in a given frame. If adjustable-speed motors for higher voltages are insisted upon, prices will be higher because of the possibility that the ratings desired may have to be engineered specially in oversized motor frames.

It must also be considered that the larger frame size of the motor will require a correspondingly larger motor housing, if such must be provided. This might increase the total costs involved to such an extent that it would be more economical to make the necessary changes to permit the use of 115 or 230 volts power supply.

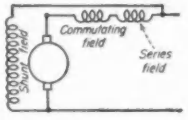
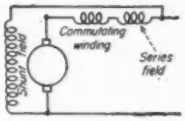
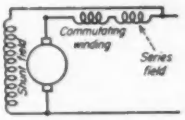
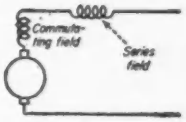
Factors Affecting Rating

The rating and, hence, cost of the d-c motor required for an application is dependent on duty-cycle. For installations, such as machine tool drives, the motor frequently used is the constant horsepower, continuous duty, adjustable speed type. A stabilized-shunt motor under field weak-

Table I—Characteristics

Type	 Plain shunt.	 Stab. shunt (constant-speed.)
Percent Series	No series.	Light series to give drooping speed-load curve.
Starting Torque	Medium. Limited by Commutation.	Medium. Limited by Commutation.
Percent Speed Regulation	5–10.	7½–15.
Speed Control	Decrease accomplished by varying armature voltage. Usually not desirable for field weakening unless part of adjustable voltage drive.	Increase by field control over 2:1 range for a wide range of sizes; smaller ranges in larger sizes. Decrease by armature voltage control.
Application	Constant-speed applications and adjustable voltage drives.	Constant-speed application requiring medium starting torque. Adjustable speed applications where the speed range is relatively small.

of D-C Motors

	Stab. shunt (adjust. speed).	Series shunt.	Compound.	Series.
				
	Light series to give drooping speed-load curve.	Approximately 50–80%.	Approximately 15–50%.	100%.
	Medium. Limited by Commutation.	Very high.	High. Depends on amount of series.	Very high.
	5–10 at base speed. 15–20 at top speed.	High, often 50–100%.	Approximately 20–25%.	Widely variable. Dangerously high no-load speed.
	3:1 and 4:1 variation by field control common. Higher ranges obtainable in special designs.	By series resistance.	Not generally used. Speed may be increased about 25% by field control.	By series resistance.
	Adjustable-speed applications requiring wide range of field control. Constant torque or constant horsepower applications.	Used where series motor characteristics are desiraole but where no-load speed must be limited to a safe value.	Used where high starting torque and fairly constant speed are desired. Used where wide voltage fluctuation is expected.	Used for very high starting torque and where a widely varying speed-load characteristic is desirable. Must not be belted to load.

ening can deliver approximately the same horsepower at top speed as at the base speed for the same power input. Hence, it is often used for such applications. The average operating speed should also be considered. A constant horsepower, adjustable-speed, continuous-duty motor is rated for a higher temperature rise at speeds below 150 percent of base speed than at higher speeds.

Tapered Horsepower

Other types of equipment such as fans, blowers, and pumps require lower horsepower at base speed than at top speed. For applications of this nature, economy is best served by specifying a tapered-horsepower, adjustable-speed motor. A typical tapered-horsepower rating is 7½/10 hp, 600/2400 rpm. Such a motor of standard open construction is designed to deliver 7½ hp continuously at 600 to 900 rpm with a temperature rise not exceeding 50C; 7½ horsepower continuously at 900 rpm (150 percent of base speed) with a temperature rise of 40C or less; and 10 hp continuously from 1800 to 2400 rpm with a temperature rise of 40C or less. For a constant-horsepower load, but intermittent operation, this same motor could be rated 10 hp adjustable speed, one hour duty, 50C rise. As such it would give satisfactory performance at a lower cost than a continuous duty, 10 hp, adjustable-speed motor.

Compound and Series Motors

Compound d-c motors are required for certain types of service. When they are supplied it is the general practice throughout the motor industry to make a slight price addition over the cost of a stabilized-shunt or plain-shunt motor of the same rating. The same addition is made for series motors. A summary of the general characteristics of series motors and compound motors with various degrees of compounding may be found in Table I.

Compound motors are used where high starting torque is required in addition to fairly constant speed. They are used for such applications as driving compressors which have no unloading devices, conveyors which start heavily loaded, pumps and mining machinery.

The series motor has a high starting torque and a highly drooping speed-load curve. It is capable of starting and accelerating heavy loads with lower current inrush peaks than would be encountered if a stabilized-shunt or compound motor were used. Series motors are used mainly for powering equipment such as cranes, hoists and winches, where the high speed regulation of the series motor results in more careful handling of heavy loads. The main disadvantage of this type of motor is its tendency to run at dangerously high speeds at very light loads. A series motor should be coupled to its load by some positive means such as a gear, chain, or coupling rather than by belt.

Where series motor characteristics are desirable but the no-load speed must be limited to some definite value, a very heavily compounded motor sometimes called a series-shunt motor may be specified.

D-c motors can be built with a great variety of speed-torque characteristics which give performance comparable to what would be obtained with counterpart induction motors. A compound-wound d-c motor, for example, may be designed to give performance similar to that obtained from a high-slip induction motor, while operating with a higher full-load efficiency. Series motors may be used to rapidly accelerate loads with lower power losses than are encountered in the case of induction motors doing the same jobs.

Temperature and Cost

Some applications of d-c motors require that they be operated in unusually high ambient temperatures. It frequently happens in applications of

this nature that the relatively expensive, inorganic Class B insulation must be used if reasonable life is to be expected. In medium size d-c motors, the horsepower which may be obtained from a given frame size is increased by the use of Class B insulation. However, it often is the case that no such increase can be obtained in certain lower ratings because of the small gage wire used. As the wire size is reduced, the ratio of copper section to total wire section is lowered. While little copper winding space may be lost in larger machines by going to Class B insulation, so much space may be lost in small motors that greatly increased current densities will tend to cancel out the advantage gained by going to a more durable insulation. In small low-voltage d-c motors, where fairly large wire sizes may be used, it is often feasible to obtain increased rating out of a given frame size by going to Class B insulation.

Some applications of d-c motors are so severe that the use of silicone insulation may be justified despite its very high cost. When considering the application of this type of insulation to d-c motors which are to have fully-enclosed, re-circulating ventilating systems, it should be kept in mind that silicone vapors, even when present in small concentrations, can have an injurious effect on commutation and brush wear.

Many of the d-c motors being manufactured for the military services must stand up under prolonged operation in extreme cold. The brushes of these motors are subject to excessive wear when the absolute humidity falls below about .15 grains per cubic foot. In warmer atmospheres, the normal amount of moisture and oxygen in the air acts as a lubricant between the brush and a complex layer of copper oxide covered by a thin deposit of graphite. The presence of oxygen and water vapor reduces the wear of the copper oxide-graphite film, and oxygen released during the electrolysis of the water vapor tends to maintain the copper oxide layer. At very high altitudes, there are reduced amounts of oxygen and moisture present in the air, a circumstance which permits the copper oxide-graphite film to be quickly worn away. The brushes then "dust" and the commutator wear becomes excessive. For high altitude applications several brush manufacturers have developed special brushes which maintain a protective film on the commutator surface. Some of these high altitude brush grades have proved very successful at extremely low temperatures when applied to low-voltage d-c machines used in tanks and Army vehicles. In one case, where ordinary metal-graphite brushes of high quality were used in a high speed d-c blower motor mounted in a military vehicle tested at —70F, it was found that armature shorts occurred frequently. Damage to the commutator was severe, and there was evidence of an excessive amount of carbon dust on all internal parts of the machine. When the ordinary brushes were replaced with a brush normally used on aircraft flying as high as 35,000 feet above sea level, no further trouble was reported. Most ordinary types of brushes may be obtained with special treatment for operation at low humidity. Such brushes are of course somewhat more expensive than ordinary brushes ordered in the same quantities. Most applications for low temperature brushes has been in the military, where the cost is not decisive.

A variety of special enclosures can be furnished for d-c motors. Some of these are illustrated in the accompanying photographs. The special enclosures add to the cost of the motor. Thus the benefits to be gained by specifying a special frame should be weighed against the economic factor. Heat dissipation and rating are also related to the choice of enclosure. The graph of Fig. 1 shows that the heat-dissipating surface per horsepower is much higher in small motors which are totally enclosed than is the case for larger ratings. In the smaller sizes it is therefore often possible to build a totally-enclosed, non-ventilated d-c motor of a given horsepower and speed rating in the same frame size as would be needed if the machine were to be open. Larger ratings, on the other hand, must be built in costly oversized frames in order that adequate heat-dissipating surface may be obtained. There is a practical limit to the rating which may be built totally-enclosed, non-ventilated with ordinary construction. Larger totally-enclosed ratings, within limits may be built with external fans.

In some cases, advantage can be taken of the ventilating characteristics of the product or machine to reduce the frame size needed. Mounting the drive motor in the path of any forced air flow aids cooling con-

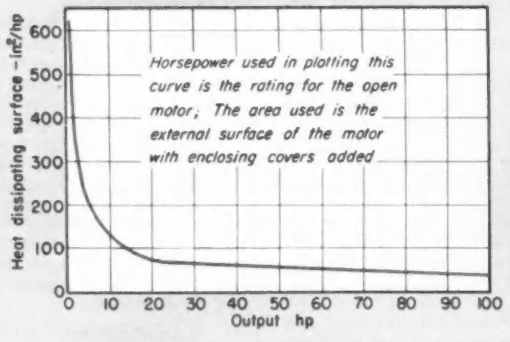

Heat dissipating surface – in²/hp
600
500
400
300
200
100
0
0 10 20 30 40 50 60 70 80 90 100
Output hp
Horsepower used in plotting this curve is the rating for the open motor; The area used is the external surface of the motor with enclosing covers added

Fig. 1 — Relationship between heat-dissipating surface per horsepower and horsepower for a line of 1,750 rpm d-c motors.

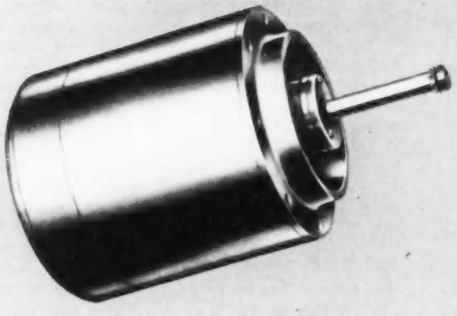


Fig. 2 — Small d-c explosion-proof motor designed for mounting in the air flow of an axial fan. Cooling effect of the driven fan makes possible a smaller than usual frame size.

siderably. The explosion-proof fan motor illustrated in Fig. 2 is an example. The cooling effect of the driven fan makes possible a smaller than usual frame size.

Brake and Gear Motors

In recent years d-c motors equipped with electrical brakes have become increasingly popular. The brakemotor, illustrated in Fig. 4, is used for applications requiring frequent starting, stopping and braking of loads. Brakemotors are being used more widely on machine tools where there is considerable starting and stopping, in positioning the tools or workpiece for example. The brakemotor is a faster, more efficient alternate in such cases, to jogging standard motors. Of course the brakemotor is more expensive than standard motors, so that again it is necessary for the product engineers to weigh performance against the increased cost.

D-c brakes may be series or shunt-connected. A series brake, when adjusted for maximum rated torque, will release on approximately 40 percent of the full-load motor current and will not reset before the current drops to about 10 percent of the full-load value. The series brake has the advantage that it sets and releases relatively fast, owing to the low self inductance of its coils. These brake coils, being wound with heavier wire than shunt brake coils, are more durable. For crane and hoist applications, the fact that the series brake will not release unless the motor is delivering torque to its load is an important advantage over the shunt brake. If a motor equipped with a shunt brake were holding a load against gravity and the armature circuit happened to open when the brake released, the load might be dropped.

A series brake does not have to be used on a series motor. It may be used on a shunt or compound motor if the operating conditions permit. For applications where the motor line current sometimes falls below 10 percent of the rated current, the shunt-wound brake should be used. The shunt brake draws substantially the same current at all motor speeds and may therefore consume more power on the average than does the series brake.

The retarding torques of various brake ratings are generally given in manufacturer's catalogs. If the brakemotor is operated on a duty cycle, it is important that the manufacturer receive data regarding the cycle of operation in order that a motor and brake having adequate heat-dissipating capacity may be selected.

The method used to stop a motor may affect the drive cost. In addition to the braking methods already described, d-c motors may be stopped by dynamic braking or plugging. Dynamic braking may be applied to any motor which may, with the proper control sequence, be made to operate as a generator. To accomplish dynamic braking, the field of the d-c motor is kept excited when the armature is disconnected from the line and connected across a suitable resistance bank. The motor then acts as a generator, continuing to rotate in the direction it has assumed while acting as a motor. While running as a generator with the original motor rotation, the initial direction of the armature current is reversed causing an electro-magnetic torque to be developed which tends to oppose the rotation. The kinetic energy of rotation is dissipated in the dynamic braking resistor and the armature resistance during the stopping period. It is the usual practice to limit the initial dynamic braking current to about 150 percent of rated current, but quicker stops may be accomplished with higher braking currents. If such more rapid than usual stops are frequently required, an oversized motor may have to be specified. Motors may be stopped more rapidly by dynamic braking if the dynamic braking resistance is reduced as the generated voltage of the motor decreases with decreasing speed. The purpose of this procedure, of course, is to keep the current and flux at a consistently high value.

In order to understand plugging, it is necessary to understand how d-c motors are reversed. Any d-c motor may be reversed by simultaneously reversing its armature and commutating winding connections or by reversing its fields. The latter method requires a field-discharge resistor for the shunt field when the reversal is accomplished by means of a controller. In the case of a compound or stabilized shunt motor, the series field would have to be reversed as well as the shunt field. As a rule the commutating and armature windings of a d-c machine are internally connected in series. It therefore is a matter of reversing only two leads by means of very simple control to reverse the direction of rotation of any d-c motor.

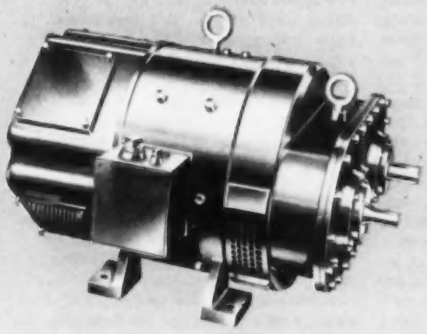


Fig. 3 — Fifty hp. d-c gearmotor provided with two shaft extensions for airplane crane — two different output speeds required. Use of one such motor proved more economical than two motors of different speeds.

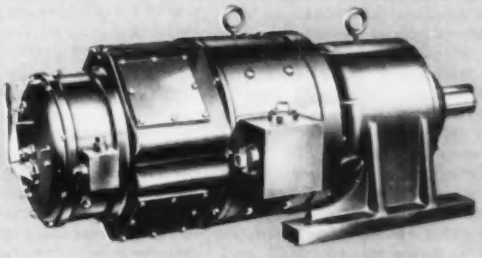


Fig. 4 — Fifteen hp. d-c gear brakemotor designed for lifting and lowering tanks between decks of LST vessels. Similar motors are used for raising and lowering submarine periscopes.

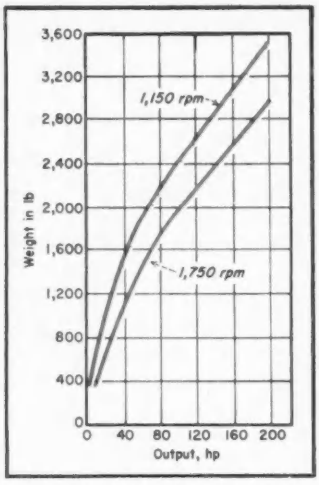


Fig. 5—Relationship of weight to horsepower for a line of general purpose d-c motors. Pounds per hp. decreases with size.

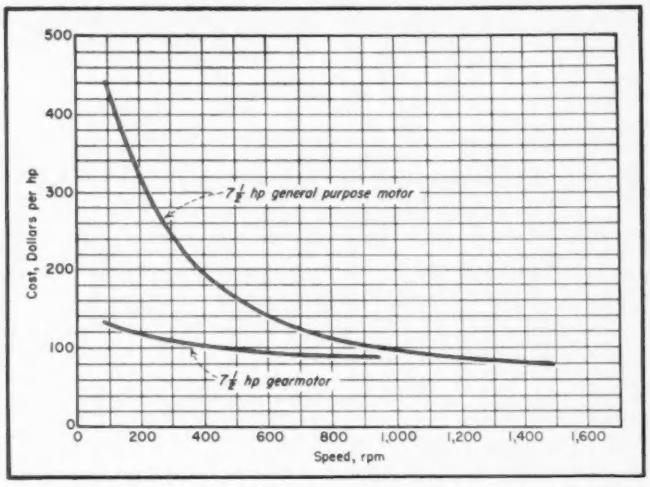


Fig. 6—Curves showing relationship between speed and cost per horsepower for typical 7½ hp standard d-c motor and gearmotor. Cost represents average prices as of Jan. 1, 1951. Below about 1,000 r.p.m., the gear motor generally costs less.

If the armature and commutating windings are reversed while the motor is still running, the counter emf of the motor and the line voltage will add up directly to produce a high current in a direction opposite from that of the normal motor current, giving rise to a high braking torque as in the case of dynamic braking. This is known as plugging. When a d-c motor is plug reversed, it should have resistance inserted in its armature circuit to limit the current peaks. The use of frequent plugging by means of a limit switch or manual control may require the use of more costly insulation or an oversized frame.

Starting as well as stopping enters into the final cost of a d-c drive. While fractional-horsepower d-c motors may in general be started directly across the line without ill effect, it is the usual practice to use some type of starting equipment with integral horsepower d-c motors. In certain special applications, however, integral horsepower d-c motors may be thrown directly across the line, thus keeping the cost of starting equipment at a minimum. For example, one hoist manufacturer builds equipment in which a loaded 6½ hp, 1600 rpm series d-c motor is successfully started directly across the line. Before using an integral horsepower d-c motor for a line-start application, many factors must be considered, including the frequency of such starts, generating capacity available, method of coupling to the load, and load inertia. Each of these elements influences the feasibility of line-starting in the projected application.

Where line-starting is considered, the d-c motor selected should be series or compound-wound. The high starting torques developed by such motors result in shortened accelerating periods and lower peak inrush currents. Where a compound-wound motor is line-started, it will come up to speed with lower starting current peaks if its shunt field is kept excited at all times. In the hoist application referred to above, the series motor used had as many commutating poles as main poles. This arrangement is desirable wherever an integral horsepower d-c motor is to be started directly across the line. It results in lower saturation of the commutating pole magnetic circuit and reduced short-circuit voltages in coils undergoing commutation.

It is common practice among motor manufacturers to build two and four pole d-c motors which are to operate at constant speed with only one-half as many commutating poles as main poles. Since somewhat better commutating conditions may be obtained by using the same number of commutating poles as main poles, this arrangement is to be preferred in adjustable- speed d-c motors designed for operation over a 3:1 or 4:1 speed range. Even though it is usual to use longer commutating poles on machines having half the maximum number, it is cheaper to make one-half as many of the longer commutating poles than it is to make twice as many shorter ones. Where a reduced number of commutating poles is used, there is a reduction in total copper loss and the weight of the copper and iron is less.

In applications where weight is an important factor, a lighter unit may be obtained by going up in speed for a given horsepower. The curves of Fig. 5 show the variation of weight with horsepower for a line of general-purpose d-c motors. Beyond a certain point, greatly increased core losses, commutation difficulties, excessive vibration and ventilation limitations make it impractical in many cases to save weight by specifying higher speeds.

For low-speed applications a gearmotor often results in a less costly, more compact unit. The curves of Fig. 6 show the relative cost in dollars per horsepower for d-c 7½ hp ratings at various speeds both as a gearmotor and as a conventional-type motor. The cost advantage of the gearmotor for low-speed drives is related to two factors. First, the motor is required to furnish less torque than would be called for from a direct drive. Second, the motor can be designed for relatively high speeds with consequent economies.

Although adjustable speed is probably the main reason for the increased use of d-c motors in recent years, speed control is a relatively infrequent consideration in fractional horsepower motor applications. Therefore, the d-c fractional offers little competition to its a-c counterpart.

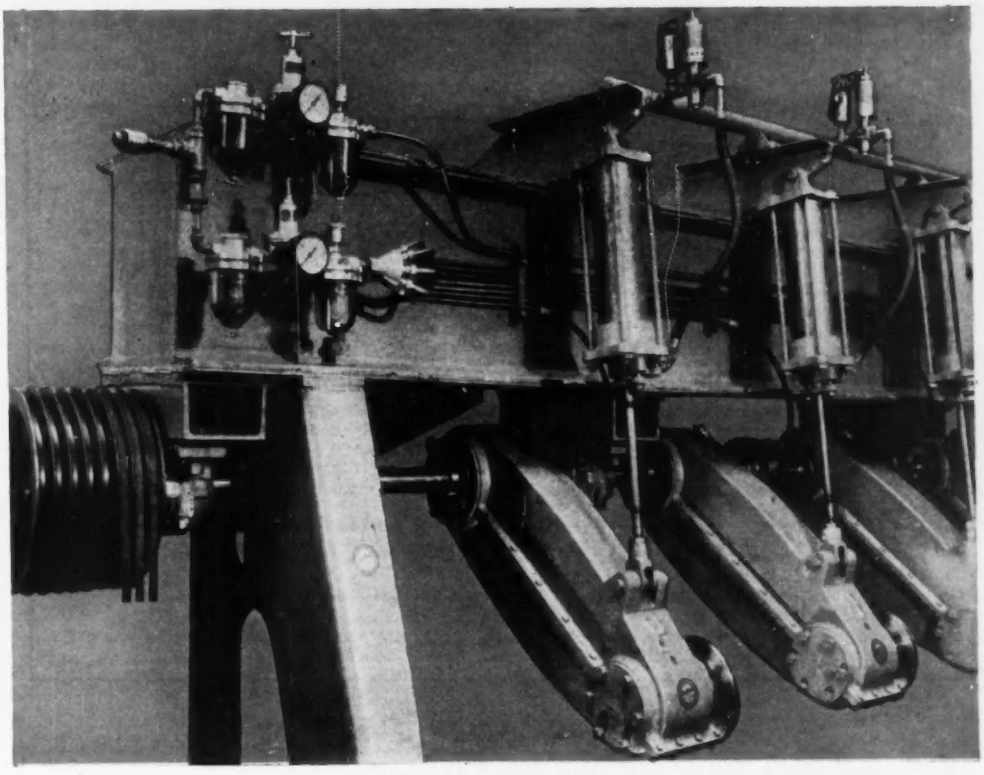


Fig. 1—Chains and spindle bearings enclosed in thirteen housings are lubricated by an oil fog produced by two lubrication units.

Wetting Characteristics Of Lubricating Aerosols

D. G. FAUST, CHIEF ENGINEER, C. A. NORGREN COMPANY

IN THE PAST SEVERAL YEARS, an intensive investigation has been conducted to determine the basic theory underlying the behavior of lubricating aerosols. Although incomplete, this study has provided sufficient fundamental information to justify a development program that resulted in the design of the Micro-fog lubricator.

To carry on this program successfully, much specialized equipment had to be designed and built. The first problems were to develop equipment that would produce an aerosol of uniform characteristics and measure the size of the fog particles. After equipment for these purposes had been obtained and standardized to the point where confidence could be placed in their performance, much interesting data were accumulated and analyzed.

Experiments indicate that a definite relationship exists between the velocity of impingement, aerosol particle size, and wetting or lubricating ability as shown in Fig. 2. These data show that the wetting characteristics of an aerosol depend upon the square of the particle diameter and the velocity of impingement upon the surface to be wetted, other factors such as quality of surface finish and temperature remaining constant.

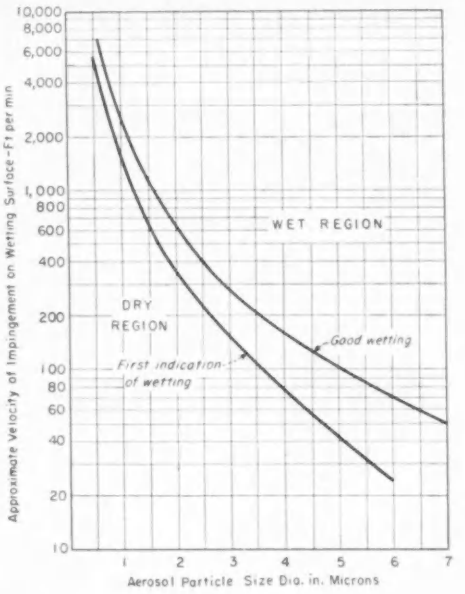


FIG. 2

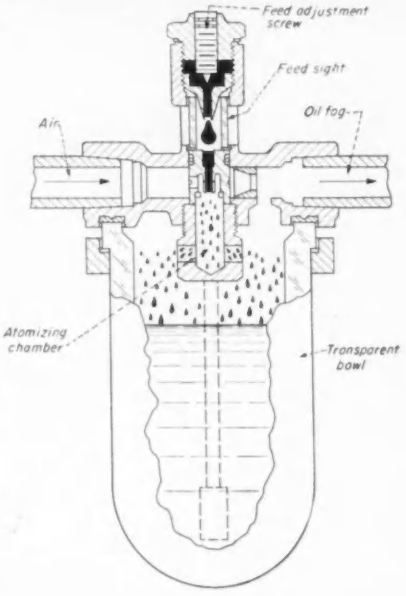


FIG. 3

Fig. 2—Effect of velocity of impingement and aerosol particle size on wetting characteristics of lubricating aerosols. Effective lubrication is achieved when particle size and impingement velocity are as defined in the wet region.

Fig. 3—Micro-fog lubricator construction for producing an airborne oil fog. The fine fog leaving the lubricator is relatively dry and becomes a wetting agent through a reclassifying action at the point of application.

Fig. 4—Recommended operating range and performance characteristics of Micro-fog lubricators. (A)—For services requiring 1 to 3 cu ft of air per min. (B)—For air tools consuming 5 to 14 cu ft of air per minute.

Where

d = diameter of aerosol particle

V = velocity of impingement

K = constant

the wetting or lubricating ability of an aerosol follows the relation

$$d^2V = K$$

For all practical purposes, the curves of Fig. 2 show the limiting conditions for partial and complete lubrication. When particle size and velocity of impingement are such that the intersection of their abscissa and ordinate is in the "dry region" under the lower curve, the wetting ability of the aerosol is not sufficient for lubrication. For conditions defined by the region between the two curves, a partial wetting is achieved. Effective wetting of the surface to be lubricated, however, is not attained until conditions are as defined by the "wet" region above the upper curve.

It is apparent from Fig. 2 that a lubricating aerosol the particles of which are 2 microns in diameter must attain a velocity of impingement of approximately 700 ft per min or greater to achieve wetting and so provide good lubrication.

In some air operated tools and devices, impingement velocities as great as 700 ft per min are not obtainable. Consequently, to wet the bearing surfaces of such applications sufficiently to provide adequate lubrication, it was obvious that the size of the oil fog particles must be larger than 2 microns.

Research studies, however, had shown that an aerosol having a particle diameter of approximately 2 microns or smaller could be conveyed through piping systems for distances greater than any usually encountered in practice. These studies had also shown that equal distribution of fog could be obtained from a number of outlets connected to the same lubricating device; and that special fittings, while desirable, were not necessary to streamline the flow pattern of the piping system.

In searching for a method to achieve adequate lubrication where impingement velocities are low, it appeared undesirable to increase the aerosol particle size of 2 microns at the lubricator. The small particle size must be maintained until the point of application is reached. A means of increasing particle sizes and reclassifying the oil fog at the point of application offered a solution to the problem.

The desired result was achieved with a small fitting or Reclassifier. In passing through this device, small aerosol particles are caused to bombard one against the other and also against the walls and labyrinths of the Reclassifier. This action results in a coagulation or combination of small fog particles into larger ones, which

at low impingement velocities readily wet metallic surfaces and lubricate them thoroughly and efficiently.

The turbulent action in the reclassifier uniformly increases the particle size of the aerosol being delivered by the lubricator. Any portion of the fine oil fog if permitted to pass through the reclassifier would detract from the efficiency of the system, in that this fine fog would not have desirable wetting or lubricating characteristics. Since large droplets are considered undesirable, all the oil fog should be reclassified, and the size of the individual particles should be fairly uniform as they leave the reclassifier.

Thus the reclassifier, which can readily be installed between the feed line and the inlet connection of any air tool or bearing housing, was developed without compromising two important performance characteristics of the lubricator: (1) Lubricating device need not be installed close to or adjacent to the equipment to be lubricated; and (2) Effective lubrication of intricate machine tools requiring multiple points of lubrication can be achieved by one lubricator without excessive concern for the piping arrangement and the use of special streamline fittings.

On new installations, it is difficult to determine in advance whether or not a reclassifier will be required. Once the installation of the lubricator is made and set in operation, however, a simple observation will indicate whether or not a reclassifier is desirable. A cloud of oil fog in the exhaust of an air operated device or bearing, being serviced by a Micro-fog lubricator, definitely indicates that the aerosol is passing through the equipment without lubricating it efficiently. The installation of a reclassifier will overcome the discharge of oil fog and assure efficient lubrication.

The method of producing the airborne oil fog with a Micro-fog lubricator can best be described with reference to Fig. 3. Air enters the inlet at the left and picks up drops of oil fed into the airstream at the center of the lubricator. Most of this oil is atomized into the space overlying the oil supply in the bowl. Droplets and heavy oil particles in the fog fall into the oil supply. Only the very fine oil particles (2 microns in diameter or smaller) are drawn into the discharge line of the lubricator.

In addition, a portion of the inlet air is permitted to flow directly through the lubricator without entering the oil reservoir. This free air combines with the airborne oil fog as it leaves the lubricator. Constant and uniform delivery of the oil fog can be precisely controlled. Fully visible oil feed provides a clear view of the rate of oil flow. Only about five percent of the oil that drips through the sight feed glass is converted into fine fog. Consequently, precision adjustment of the oil feed is possible and metering to one drop of oil in five minutes is not unusual.

The operation of the lubricator is completely automatic, it operates only when air flows. A ball check in the oil feed tube holds the lubricant in position between brief intermittent operations, thus assuring immediate flow the instant air is turned on. Automatic operation and precision adjustment of oil feed reduce to a minimum the possibility of oil flooding the lines or equipment being lubricated.

No liquid oil is directed into the air line. The oil fog is created in the chamber overlying the oil supply, only the fine fog enters the air line. This fine fog is relatively dry and becomes a wetting agent only through some form of reclassifying action at the point of application.

The oil fog delivered by the lubricator is of predetermined particle size and remains in suspension in the air, thus it is possible to convey the fog long distances through the piping system. The position of the lubricator in relation to the equipment served, therefore, is not a critical consideration. In addition, uniform distribution of oil fog to multiple units in simultaneous operation is possible.

At present, the Micro-fog lubricator is made in $\frac{1}{4}$ and $\frac{3}{8}$ in. pipe sizes and two oil capacities, $\frac{1}{2}$ and $\frac{1}{4}$ pint. Although the external appearance of all lubricators of this type is identical, internal constructions differ to provide maximum performance for either of two distinctly different operating conditions.

An arbitrary standard has been established for the specification of operating range. All ratings are based on an applied line pressure of approximately 80 psi. The minimum air flow

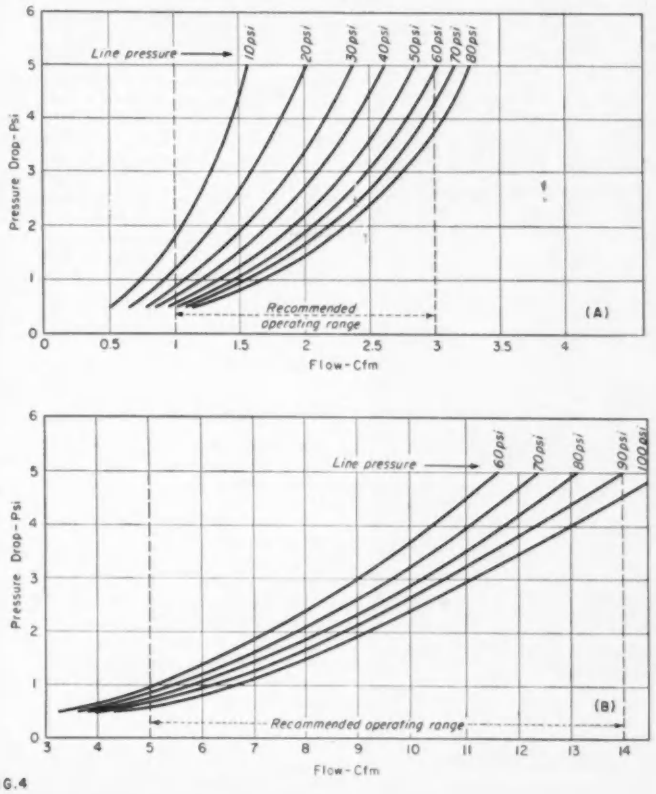


FIG. 4

that gives satisfactory performance is taken as the lower limit of the operating range. The recommended maximum air flow is that which produces a pressure drop of approximately 5 psi across the lubricator.

Air flow should not be less than the minimum recommended. The maximum recommended air flow may be exceeded and satisfactory performance still obtained, however, under such conditions it must be expected that the pressure drop across the lubricator will exceed the rated 5 psi. If increased pressure drop does not jeopardize the function of the system being lubricated, operation of the lubricator at air flows higher than the rated maximum is permissible.

In Fig. 4(*A*) are shown performance characteristics of the Micro-fog lubricator designed primarily for servicing high speed bearings and air operated devices requiring small amounts of air, and where generally a reclassifier is required to obtain maximum efficiency.

When lubricating bearings, a line air pressure of approximately 10 psi is generally adequate. At this pressure, the free air consumption will be approximately 1 cu ft per min. For lubricating devices having a free air requirement of approximately 1 to 3 cu ft per min, this lubricator can be used up to 125 psi operating pressure.

Successful lubrication of small dies and punches on blanking, forming, thread rolling, and other machining operation is also possible. This type lubrication, however, is limited to small metal forming jobs that require only a thin film of oil. On such applications, a reclassifier is generally installed within an inch or two of the tool or part to be lubricated.

The performance characteristics shown in Fig. 4(*B*) are those of the Micro-fog lubricator intended for use with small air tools having an air consumption of from 5 to 14 cu ft per min. This lubricator is generally operated at line pressures of from 60 to 100 psi but is safe for operation at pressures as high as 125 psi. The inherent characteristics of most of these applications are such that a reclassifier is not necessary. Occasionally a reclassifier is desirable, however, to overcome an objectionable discharge of oil fog and to improve the lubricating efficiency of the system. Actual trials are usually necessary to determine whether or not a reclassifier is required on any particular application.

One application that is indicative of the flexibility of installation that is afforded by aerosol lubrication is shown in Fig. 1, which is a partial view of a 13 position trimmer used in the lumbering industry. A common countershaft drives 13 trimmer heads through individual chain drives. Each chain drive is enclosed in a housing, which also encloses four bearings that support a trimmer head spindle.

Two complete lubro-control units, connected in parallel to an air supply, are mounted on the left hand side of the machine frame. Each unit includes a filter, a regulator and a Micro-fog lubricator.

The discharge from one lubricator is fed to an aerosol distributing head having six outlets; the discharge from the other is fed to a distributing head having seven outlets. Feed lines from the distributing head outlets to the chain drive housings convey the oil fog for lubrication of the chains and the trimmer spindle bearings.

A thread rolling operation on a flash gun battery case is shown in Fig. 5. A lubricator discharges oil fog on the battery case and tool as the thread is being rolled. A Reclassifier is used at the point of discharge to improve the lubricating properties of the fog and to prevent it discharging into the atmosphere in the vicinity of the operator. Considerable savings and increase of production capacity have been realized by this method of lubrication. In the previous method, which was time consuming, wasteful and dirty, the operator dipped the battery cases in oil or brushed oil on the cases.

In all installations, piping arrangements are simplified by the inline inlet and outlet connections of the lubricators. Units are made for either left to right or right to left flow. The lubricators can be completely disassembled for inspection and cleaning without removal from the air line.

Lubricants are conserved. The finely divided oil fog spreads oil uniformly over the surface requiring lubrication and thoroughly lubricates even closely fitted moving parts.

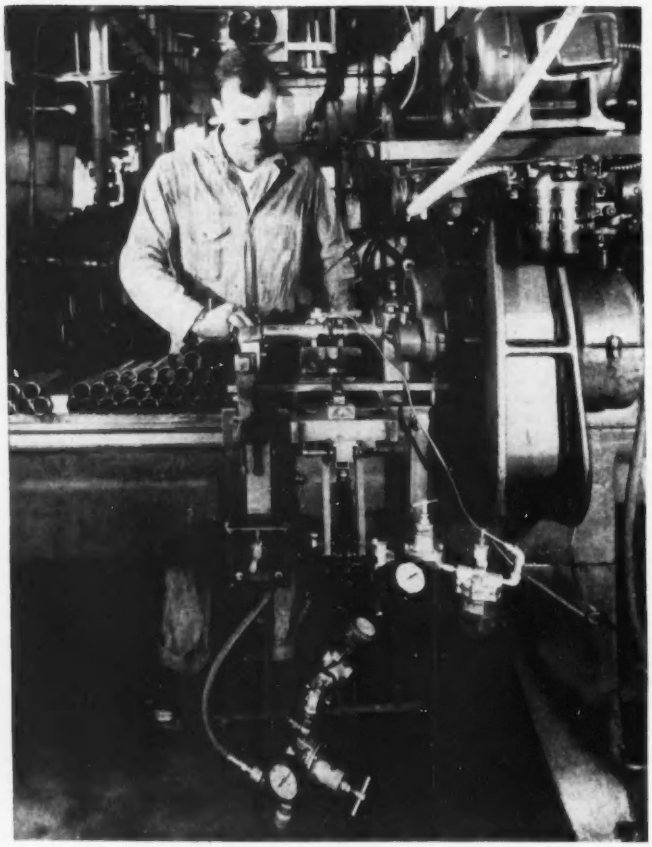


Fig. 5—Lubricator discharges oil fog on battery case and tool in thread rolling operation. Reclassifier at discharge point improves fog lubricating properties.

Workman makes final inspection of leads before motors are shipped to detect breaks in the insulation.

Power Leads for Fractional Hp Motors

Short-lived motor leads are harmful to a products reputation. This is especially true of fractional hp motors—most of which go to the mass consumer market. Assure good performance by careful selection of lead materials and construction.

A. L. ULMER
Fractional Horsepower Motor Division
General Electric Company

THE FACTORS INFLUENCING THE CHOICE of motor leads are mechanical as well as electrical in nature. The cross-sectional area of copper needed to carry the motor current is determined from electrical calculations. But most of the considerations that determine the service life of the wire or cable are mechanical problems.

Once size is decided upon, lead materials should be selected on the basis of the following questions, listed in the approximate order of importance.

1. What are the anticipated operating conditions?
2. What degree of flexibility is needed?
3. Is braided or braidless cable preferred?
4. Does the application call for color coding or other identification system?
5. What temperatures will be encountered?

With regard to the first question, the prime consideration is the resistance of the insulation material to the atmosphere surrounding the lead in service. One application may find the motor in a laboratory, where the air is free from dust, gases, solvents and

Table I—Common Types of Lead Insulation

A—1/64-in. wall, rubber tube, cotton braid, lacquer finish

B—1/32-in. wall, rubber tube, cotton braid, lacquer finish

C—1/32-in. wall, neoprene, braidless (75C)

D—Glass wrap, glass braid, silicone varnish

E—1/32-in. wall, neoprene, tube, braidless (90C)

F—Teflon wrap, glass braid, silicone varnish

G—1/32-in. rubber tube, close-weave cotton braid, lacquer

H—1/32-in. wall rubber tube, coarse cotton braid, lacquer

I—Thin wall, thermo-plastic, braidless

J—Thin wall, thermo-plastic, braidless, nylon jacket

K—1/32-in. rubber tube, single-crossover cotton braid, lacquer

L—1/32-in. wall, thermo-plastic tube, braidless

M—#12AWG—acetate, cotton braid, lacquer finish

N—1/32-in. rubber-like tube, soft cotton braid, lacquer

O—Teflon wrap, glass braid, Teflon enamel finish

(See Table II for characteristics of these leads)

Table II—Characteristics of

Lead Type	A	B	C	D
Temp. Rating	75C	75C	75C	125C
Voltage Rating	300	300	300	125
Dielectric Breakdown Voltage	Excellent	Excellent	Excellent	Low
Cost	Nominal	Nominal	Nominal	Nominal
Max. Overall Dia. in.	0.128	0.155	0.114	0.095
Stripping	Good	Good	Good	Poor
Flexibility	Good	Good	Good	Good
Abrasion	Good	Good	Low	Low
Fungus Resistance	Low	Low	Excellent	Low
Braid	Cotton	Cotton	.....	Glass
Braidless	———	———	———	———
Oil Resistance	Low	Low	Excellent	Low
Varnish Treatment	Fair	Fair	Excellent	Fair
Colors	All	All	All	One

oils. Temperature and humidity may be rigidly controlled and the motor may operate on light duty cycle.

An example of the other extreme is a location where temperature and moisture conditions vary widely. The air is filled with dust, gases, solvent or oil vapors and the motor may be operated continuously at full load or under a severe duty cycle. Another difficulty arises from the fact that the fractional hp motor, being small in size, is often concealed within the machine. It is given attention only when the driven machine ceases to function properly and may be neglected entirely for long periods. Oil, dust and other air-borne particles accumulate on and within the motor frame, attacking the lead insulation.

Unfavorable conditions are encountered much more frequently than ideal conditions. Most lead materials will suffice for the latter type of service. But careful selection of insulation is called for in the great majority of applications. In Table I are listed the various types of leads available for use on fractional horsepower motors. The characteristic data on these leads are given in Table II. The columns of Table II relating to oil resistance, varnish treatment (moisture resistance) and fungus resistance must be given most attention if it is anticipated that unfavorable atmospheres will be in contact with the leads.

Copper Construction

Internal connections on fractional horsepower motors should be made with flexible conductors because the motors are small and space is limited. It is usually necessary to twist or bend the leads to fit the clearances between the motor frame and the internal structure. In addition, some motor applications are subject to severe vibration, as on a sand riddle for example. Here a rigid lead material would fail due to fatigue of the insulation and the conductor. The flexibility of stranded copper conductor is definitely required in such cases. External motor leads are practically always of stranded construction for reasons of flexibility.

The individual strands of the conductor may be either bare or tinned. Usually, where rubber compounds are used for insulation, the copper strands are tinned to prevent the formation of copper sulphide by a chemical reaction between the copper and the sulphur in the rubber compound. Where no sulphur is present in the compound, bare strands are satisfactory. For some applications bare copper strands are preferred, since they are more flexible and easier to fasten to crimp-type terminals. In others, the advantage of tinned copper strands for easy soldering operations is desired. Stranded conductors have a pitch or lateral lay varying from 0.7 in. to 2.25 in., which serves to retain the strands as a unit conductor. Flexibility increases with decrease in pitch of the strands.

Braided Insulation

For easy stripping it is customary to apply a cotton thread or a thin paper wrap over the stranded conductor. This serves as a barrier and prevents the entrance of the extruded rubber or synthetic tube into the interstices of the stranded cable. With this construction very little difficulty is experienced when stripping the lead, either by automatic machine or by hand methods. Also, a soft cotton or a glazed cotton braid is normally applied over the extruded tube of insulation. This serves as mechanical protection for the lead, guarding against abrasion. A lacquer finish coat is applied over the braid for appearance, protection against ordinary solvents and varnishes, and to exclude moisture and foreign particles to maintain

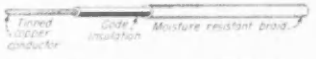


Fig. 1—Construction of typical braided motor lead. Electrical insulation is supplied by material extruded directly over the copper conductor. Fabric braid supplies mechanical protection for the insulation material.

Motor Leads (See Table I for description of lead types)

E	F	G	H	I	J	K	L	M	N	O
90C	200C	75C	75C	60C	60C	75C	80C	75C	75C	204C
300	300	300	300	600	600	300	300	300	300	1000
Excellent	Excellent	Excellent	Nominal	Medium	Medium	Fair	Good	Medium	Excellent	Excellent
Nominal	High	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	High
0.158	0.101	0.150	0.155	0.080	0.088	0.148	0.097	0.143	0.154	0.110
Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Excellent	Fair	Good	Good	Good	Good	Good	Fair	Fair	Good	Fair
Medium	Fair	Low	Good	Low	Medium	Good	Medium	Good	Good	Good
Excellent	Fair	Low	Low	Excellent	Excellent	Low	Excellent	Low	Low	Excellent
———	Glass	Cotton	Cotton	.....	.....	Cotton	.....	Cotton	Cotton	Glass
———	———	———	———	———	Nylon Jacket	———	———	———	———	———
Excellent	Fair	Low	Low	Fair	Good	Low	Fair	Fair	Fair	Excellent
Excellent	Good	Fair	Fair	Fair	Good	Fair	Fair	Fair	Fair	Excellent
One	One	All	All	All	All	All	All	All	All	One

a high dielectric strength. The insulation shown in Fig. 1 is typical.

A braided surface is particularly favorable to fungus growth. Regardless of whether the braid is rayon, nylon, or glass, it is vulnerable to fungus growth, because the braided surface retains small interstices between the threads which are not closed completely by the usual braid finishes. Even a closely braided, single crossover, glass braid is subject to fungus attack. It is necessary, therefore, to specify a protective coating for braided leads that are to be installed in hot, humid locations.

The pattern of a braided lead presents a pleasing appearance, so that braided leads used within the motor can be brought thru a bushing in the motor frame and made to serve also as external leads. Braided leads are generally satisfactory for external use because of the mechanical protection offered by the braid.

Where it is necessary to provide identification for a number of leads from a given motor, cotton braids can be supplied in destinctive color patterns. The cost of color coded braids is greater than the cost of black colored leads. But the added cost is offset by the convenience afforded at installation of the motor. Complete selections of colored cotton covered leads within the A.S.T.M. color range are available from many manufacturers. Some applications may require more than standard color range. Small tabs with imprinted characters or metallic markers with stamped characters permit positive identification. At least one lead supplier provides a spiral color code which has thousands of possible color combinations. The most satisfactory methods of identifying leads are those that retain their coding permanently, although leads are cut off or reduced in length.

Braidless Leads

The trend today is toward a braidless lead construction for fractional horsepower motors, even for internal wiring. The sketch in Fig. 2 shows the construction of braidless leads.

A difficulty encountered by the users

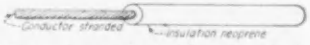


Fig. 2—Section of a braidless motor lead. Insulation material must be tough to resist abrasion since it has no protective braid.

of fractional horsepower motors is the penetration of varnish at the section where the leads are attached to the field coils. This condition is particularly true of braided leads. The use of braidless leads makes the problem somewhat less difficult. In braided leads, the trouble occurs when the lead near the coil is flexed back and forth during normal handling in the manufacturing processes. This causes the varnish or lacquer on the braid to crack, providing easy access of the baking varnish into the braid. After the baking operation, that portion of the lead is hard and brittle and further handling may lead to breaking of the braid. Several of the available braidless leads have shown a consistant resistance to any evidence of damage at this location due to baking varnish, the baking cycle, or to flexing after the baking cycle.

The plastic flow requirements for leads are easily met by leads with good braid construction. The braid distributes the pressure per unit area under test and prevents the deformation of the insulation to a point where dielectric breakdown could occur. A braidless lead must be so constructed that the insulation used will withstand the same conditions without benefit of the braid. Resistance to plastic flow is especially important in leads that are thermoplastic insulated, with or without a nylon jacket. When these are used in small motors where the "hot-spot" temperature may be high, the insulation tends to flow from pressure areas, such as bends or clamp-down points. In time, the lead is bare of insulation at these points and the danger of grounds exists. Thermoplastic insulation is furnished on wires as small

as No. 30 A.W.G., stranded.

Recent applications indicate a growing demand for wire insulation with temperature characteristics far beyond the present standards. This is particularly true of military usage. Specifications may call for satisfactory operation at temperatures anywhere within the range from minus 125 F to plus 400 F. Many insulations suitable for motor leads a few years ago cannot satisfy present requirements. From paper, cotton, rubber, silk and rayon, the designer must now move toward glass, ceramics, the higher temperature thermoplastics, silicones, Teflon, Asbestos and others.

Today, 400 F (204 C) is often specified as a rated temperature for motor leads. This compares with the 90 C (194 F) considered high only a few years ago. With new and better materials available, ratings are being increased or the physical size of motors reduced to meet the demand for more power in a smaller package. The

Fig. 3—Sketch illustrating construction of one of the newer lead materials. Teflon is the insulating material, with a glass braid for protection against mechanical damage.

insulation for one such lead material is a fused Teflon wrap, glass braid, with Teflon varnish. A section of this lead is shown in Fig. 3. The fusing operation combines the entire insulation assembly into a unit mass. Voltage rating of this lead is 1,000 volts, temperature 400 F and a dielectric breakdown test was made at 16,000 volts.

This particular cable has a low temperature limit of minus 112 F (—80 C) at which point it can be bent without cracking the insulation. Generally, the thermoplastic types of cable become more rigid at low temperatures with a tendency to harden and possible breakage when subjected to severe handling. Cables made of rubber with braid, or neoprene with or without braid may be used at —40 F (—40 C) satisfactorily.

In the high temperature applications a color code material is not available. Neither can the leads be colored readily. On those applications with two or more external leads it will be necessary to devise a practical method for lead identification. At present, the small metallic bands appear to be the only solution, with a stamped character for each lead. Possibly, a metallic band with a high temperature baked on colored enamel could be provided for identification.

Applications of Motor Leads

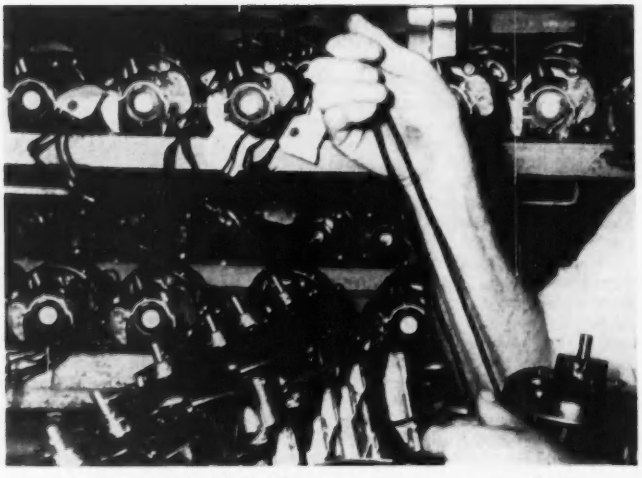
A small lead with $\frac{1}{64}$ in. wall, rubber tube, cotton braid and lacquer finish, has an overall diameter of .128 in. for No. 18 A.W.G. size. This type is recommended for use where space is at a premium. The voltage rating of 300 and a 75 C temperature rating, combined with the small diameter, makes this a suitable lead for applications such as small fan motors, business machines and motor driven typewriters.

For general use where a higher temperature rating is needed, or where operating conditions are more severe, the lead with $\frac{1}{32}$ in. wall, rubber tube, cotton braid and the lacquer finish is found satisfactory. This lead is rated for 300 v and has a 75 C temperature limit. A typical application is for internal wiring of a washing machine motor, where the $\frac{1}{32}$ in. wall of the rubber tube provides adequate insulation, and the braid with its lacquer finish protects the rubber from abrasion, oil, and cleaning solvents which may come in contact with the motor. In warm and humid climates, further protection would be necessary to guard against fungus attack.

The problem of the hermetically sealed motor is slightly different. Here a material must be used which will meet the requirements electrically, mechanically, and in addition will not affect the conditions existing in the complete hermetic system. A satisfactory insulation to meet this condition is a clean, washed, cotton braid. It must be very low in extractables, good dielectric, and free stripping. This type of lead is usually a No. 16 A.W.G. size and composed of many strands of fine bare copper wires. Thus, the insulation, consisting of four braids surrounding the conductor, should be uniformly firm to permit clean cutting of the cotton threads without unwarranted cutting of the copper strands. Leads having two wraps of cotton, then two braids, instead of the present four braids would have lower initial cost. But the saving in cost would be more than offset by difficult stripping, increased manufacturing losses, and possible customer complaints.

For moderately high temperatures and dry locations, the designer can specify leads insulated with glass. One type is made of two glass wraps and a glass braid with silicone varnish finish. This lead should be used only where it will not be subjected to excessive handling and abrasion. The principle attribute is resistance to high temperature. It is low in dielectric strength and moisture resistance, and frays excessively when stripping.

Among the synthetic insulated braidless leads, a wide variation of materials is used. All of these materials are extruded on the conductor and are available in the large selection of colors necessary for applications requiring a high degree of lead identification. Generally, the braidless leads are very flexible, and have a comparatively small overall diameter and strip as readily as the braided type of lead. Dielectric strength is ample. Features are the competitive-to-lower cost and freedom from fungus attack. A colored modified neoprene meets the plastic flow test, but is low in abrasion resistance.



Lead length, being checked here, is important for easy installation.

Designing for Economical GASKETING

E. C. FRAZIER
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THREE PRINCIPAL FACTORS govern the design and specification of gaskets: (1) the cost of the gasket (2) the cost of assembly and (3) the type of joint to be sealed.

The most economical gasket has the least volume of material and the simplest shape consistent with application requirements. To realize this ideal, joint design should be correspondingly simple, for frequently, joint simplification results in longer gasket life, a better safety factor, or both. However, the design, selection of material, and manner of specifying gaskets also has a significant effect on joint cost and effectiveness.

MATERIAL SELECTION. Most of the materials in general use as gaskets can be classified under the following headings:

1. Plain Paper—Manila, Tagboard, Chipboard, Rag and Felt.
2. Cork Composition
3. Vegetable Fiber (saturated papers)
4. Compressed Rubber-Asbestos
5. Cork-and-Rubber or Cork-and-Synthetic-Rubber
6. Sheet Rubber, Synthetics, Plastics.
7. Molded Rubber, Synthetics, Plastics
8. Copper-Asbestos or Steel-Asbestos.

Taking into consideration only the basic sheet costs, the relative cost of the different commercial classes of gasket stocks is approximately in the order of this listing, although there are of course numerous overlappings due to the existence of grades within classes, but the above statement may be accepted as a broad generality. Therefore, there is no point in specifying cork if plain paper will do the job, and treated fiber stocks need not be considered if cork composition is satisfactory.

However, the type of joint, fluid to be sealed, or other conditions often necessitate the selection of a specific material. For example, copper or steel reinforced asbestos gaskets are specialized types that are used for automotive cylinder heads and for sealing in certain oil field equipment. In the chemical industry, certain high pressure reactions require metal gaskets of this sort—or even gaskets made entirely of metal, such as stainless steel. While these are engineered gaskets for specialized applications, and beyond this brief reference will not be discussed in detail, the nature of the application also affects the selection of common gasketing materials. Table I indicates the characteristics and applications of various types.

GASKET THICKNESS—Various authorities have developed formulas for computing thickness of gaskets. However, this usually is determined by rule of thumb—using the thinnest gasket that will do the job. "Doing the job" means compensating for the irregularities in the flanges and the accumulated tolerances that exist at the gasketed joint due to manufacturing irregularities in the parts.

Where alternate materials are considered, the thicknesses of each may well be different. Consider, for example, an application where either vegetable fiber or cork composition would be suitable. If a thickness of $\frac{1}{32}$ in. is satisfactory for the relatively firm fiber material, $\frac{1}{16}$ in. would probably be better for the cork composition. In fact, cork composition gaskets should rarely be considered in thicknesses less than $\frac{1}{16}$ in. because they are likely to be unduly fragile and not have the desired compressibility characteristics. Whenever possible, standard or commercial thicknesses should be specified. In many materials, these standard thicknesses are $\frac{1}{64}$, $\frac{1}{32}$, $\frac{1}{16}$, $\frac{3}{32}$, and $\frac{1}{8}$ inch. If design calculations have developed a theoretically proper thickness of 0.025 in., it is often better to specify $\frac{1}{32}$ or 0.032 in. thus obtaining a gasket that is probably available at a lower cost. This is particularly true with materials which are sliced to thickness, calendered, or formed on paper machinery.

SHAPE FACTORS. Every designer knows that as a general rule die cut parts are cheaper than molded parts. Hence, special cross sections obtainable only by molding are avoided whenever possible. However, certain drafting conventions are often carried from the metal parts to gaskets and these may impose unnecessarily high costs. Bevels, radii, fillets, broken corners, are generally useless and costly because they require turning, sanding or machining operations, whereas it is often possible to select a gasket material that will adapt itself to the mating members with no need for these special operations.

In the case of ring gaskets, it will often pay to consider the use of a rubber-type of material which can be extruded and mandrel cut at costs appreciably less than a ring that is die cut from a lower-priced sheet material. Irregular contours and bolt holts can often be eliminated in favor of plain rings which can then be sliced from tubes.

A designer will sometimes give his gasket supplier a headache unknowingly by locating bolt holes close to the edge of the gasket. The delicate section which remains serves no useful purpose, is subject to fracture, and may impede the stripping of die-cut parts from the blanks. Such gaskets will often cost less if the bolt hole is eliminated in favor of a notch.

TOLERANCES. Because resilient materials deform under tool and die pressures, and are often sensitive to atmospheric conditions to some degree, they cannot be processed commercially with the same precision as can metal. Gasket manufacturers will gladly inform prospective users as to their standard or customary tolerances. These will generally be wider in the

case of soft compressible materials than with hard rigid stocks. Conversely, close tolerances are not likely to be required with the softer, more compressible materials. In all cases, commercial tolerances should be tried before special standards are imposed.

Designing Gaskets for Rapid Assembly

A gasket must not only make a satisfactory seal and be available at an economic price—it must also lend itself to easy and rapid handling on assembly lines. Some of the principles to be followed in attaining this "extra" are the following:

1. A stiff gasket is better than a floppy gasket. A manufacturer of automotive tail lamps was using soft sponge rubber gaskets, many of them designed with narrow wall sections. While excellently adapted to sealing and cushioning between glass or plastic lens and reflector, the gaskets were difficult to handle on the assembly line. This manufacturer was willing to pay a higher cost for a laminated construction consisting of a thin layer of fiber on one side of the sponge rubber, because of the faster assembly that resulted. Still later, he found a composition of cork and sponge rubber which had adequate compressibility but was stiffer than the plain unbacked sponge rubber, and was less expensive than the laminated construction.

2. Gaskets which are almost, but not quite, symmetrical, Table II, should be indexed for rapid positioning on the flange. A circular gasket with bolt holes not equally spaced will be easier to assemble if an indexing notch or an extra hole is incorporated in a position to correspond with some distinguishing feature or projection on the flange. Of course, the problem will not exist if care has been taken in the initial design stages to make the gasket and the joining surfaces entirely symmetrical so that no difference exists between top and bottom or right or left.

3. Gaskets which are large might assemble easier if supplied in sections with interlocking joints. This will also be a cost saving measure in many instances. In still other cases, it may be necessary to accept the gasket in sections due to limitations in the size of the specified type of sheet material, or the presses which the gasket manufacturer employs.

4. Where the character of fit within a recess is critical, the gasket supplier will do better by working from an approved sample of the mating part rather than from a drawing. A certain manufacturer's assembly required inserting gaskets within a cover. After the gasket was assembled, the cover was turned over. This condition required a fit which no manufacturer could comply with by working from a drawing. The problem was solved by the use of cut-and-try methods, using sample covers for determining dimensional adjustments.

5. If surfaces are oily at the time of installation, gaskets may slip out of position; rubber gaskets are particularly susceptible to slippage on greasy or smooth surfaces. Thus, the presence of grease, cutting oils, or wet adhesive can upset load calculations based on dry rubber placed between clean, non-skid plates. One of the distinctive properties of cork is its non-skid characteristic when exposed to oil. Thus, where oily flanges are a problem, the use of a cork-and-synthetic-rubber or a cork composition gasket may greatly speed up the assembly.

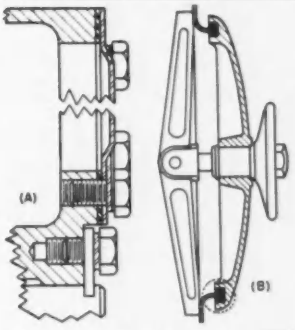
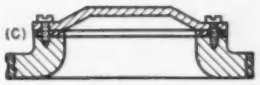
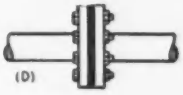
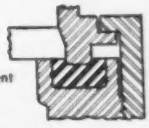
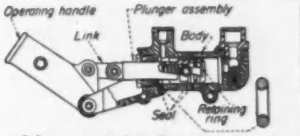
Effect of Joint Design on Gasket Specification

The type of flange design to be used is perhaps one of the most important factors to be considered in arriving at a gasket specification. The kind of joint needed is determined by the sealing requirements. For example, precise alignment of internal parts may demand a metal-to-metal design so that variables in gasket thickness or compressibility, and of production line bolt tightening are eliminated. In that event, the flange must be designed to allow for a gasket channel. This particular design works best with a gasket material that is truly compressible—one whose volume is actually reduced when placed under a compressive load. Cork-and-rubber compounds are made to order for this kind of assembly. However, non-compressible gasket materials such as straight rubber may be used if relief for flow or displacement of the gasket compound is provided either by the size of the gasket channel in relation to the gasket cross section, or by suitable shaping of the gasket itself. A rubber "O" ring, for example, might be used successfully. Because of their low compressibility, firm, rigid types of gasket materials such as vegetable fiber, rubber-asbestos and metal-encased constructions are generally not practical with this type of flange.

Flange finish must be considered in relation to the type of gasket material demanded by operating conditions within the assembly. If a soft resil-

CLASS
PLAIN PAPER (Manila, Tagboard, Chipboard, Rag Felt, etc.) *A*
CORK COMPOSITION *B*
VEGETABLE FIBER (Saturated papers) *C*
COMPRESSED RUBBER-ASBESTOS *D*
CORK-AND-RUBBER (Or Cork & Synthetic Rubber) *E*
SHEET RUBBER, SYNTHETICS, PLASTICS *F*
MOLDED RUBBER, SYNTHETICS, PLASTICS *G*
* Gaskets for extreme conditions and

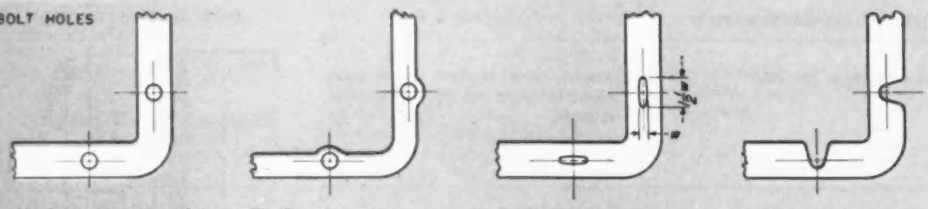
TABLE I—PROPERTIES AND USES OF GASKET MATERIALS*

SPECIAL CHARACTERISTICS	GENERAL USES	TYPICAL CONSTRUCTION
Accurate thickness, low cost.	Spacers, dust barriers, splash seals, where breathing and wicking not objectionable.	
Versatile, dependable general-purpose material. Variable as to binder, texture and hardness (density). Truly compressible. High friction whether dry, wet or oily. Low cost. Excellent oil and solvent resistance. Poor resistance to alkalies and corrosive acids.	For mating rough or irregular parts, as glass, light stampings, unfinished castings. Oil sealing at lowest cost in normal range of temperatures and pressures.	
General-purpose material having better tensile strength than cork composition, but less compressibility. Good oil, gasoline and water resistance, but alternate wet and dry cycles may cause shrinkage and hardening.	For machined or reasonably uniform flanges where adequate bolt pressures can be applied. Relative firmness and high tensile strength permit use of thin gaskets to give good alignment of covers and connected parts.	
Tough and durable. Dimensionally stable. Relatively incompressible. Good steam and hot water resistance. Oil and solvent resistance determined by characteristics of rubber binder.	For heavy duty bolted and threaded joints, as in water and steam pipe fittings, manifold connections.	
Provides fluid barrier and resilience of rubber with compressibility of cork. Properties of flow versus compression subject to controlled variation according to proportions of cork and rubber. Some sacrifice of rubber's tensile and elongation properties. Chemical properties about same as base polymers. Higher in cost than cork composition or fiber types, but lower than straight rubbers. Does not extrude from joint. Die cuts well. High coefficient of friction.	For general-purpose gasketing, except steam lines, combustion chambers, etc. Enables design of metal-to-metal joints with gasket positioned in channel or counter-bore and with no allowance for flow. High friction keeps gasket positioned even where closing pressure is not perpendicular to flange faces.	(E) Cork and rubber gasket for automotive tail light
Highly variable according to compounding, hardness, modulus, fabric reinforcement, etc. Generally impervious, but entirely incompressible.	For installations involving stretching over projections, or where flow of gasget into threads or recesses is desired. For lowest compression-set and maximum resistance to fluids such as alkalies, hot water and certain transformer oils.	 (F) Buna N gasket for petroleum equipment
Same as sheet rubber, plus shape factors permitted by molding.	For special design and assembly conditions. Example: "O" rings in square grooves permitting concentric sleeves or cylindrical shells to be assembled with a rolling gasket between.	 (G) "O" ring seals for hydraulic pump

special purposes involve materials and construction of such variety that detailed discussion here is not feasible.

TABLE II—DESIGN SUGGESTIONS FOR GASKETED JOINTS

BOLT HOLES



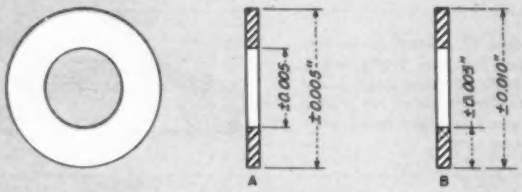
(A) Satisfactory construction when the width of the gasket is sufficient to allow at least ⅛ in. between bolt holes and the edge of the gasket.

(B) To obtain sufficient material around bolt holes to prevent blow-out or damage during assembly, ears or projections can be used.

(C) Oblong holes prevent damage to extra large or long gaskets during assembly, permit looser tolerances, and therefore decrease gasketing cost.

(D) Notches for bolts are practical in many instances and result in less costly gaskets than if projections are used.

TOLERANCES



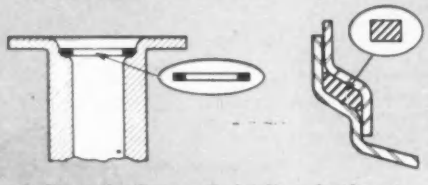
Commercial Thickness Tolerances of Representative Gasket Sheets, 1/16 in. Nominal Thickness*

Material	Tolerances, in.
Cork composition	∓0.010
Cork-and-rubber	∓0.015
Vegetable fiber	±0.006
Molded sheet rubber	±0.015
Calendered stocks — rubber, plastics, etc.	∓0.005

*Due to equipment and processing variations, these values are rough indications only. In general, tolerances are closer for thinner sheets, wider for heavier gages.

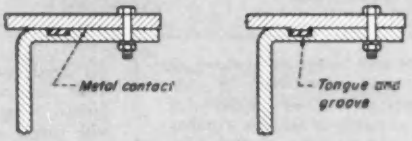
(G) Holding close tolerances on gaskets increases costs. This ring gasket can be made to tolerances called for at *A*, but at about twice the cost of gasket *B*. Close thickness tolerances seldom are justified, the table giving nominal commercial values.

RADII FILLETS
IRREGULAR SHAPES



(I) Fillets and radii are usually desirable on forged or machined metal parts — but not on the gasket used with them. Because gasket material will deform, curved edges and corners, or irregular shaped gaskets, frequently are unnecessary.

FLANGE CONSTRUCTION



(J) Suggested gasketed construction when metal to metal contact is required between mating flanges. Relief and side flow allowance must be used except for compressible material.

(K) Tongue and groove construction is more expensive than previous flange, may provide more positive seal.

ient material can be used, it may be economical to leave the flange relatively rough. The gasket will fill any normal irregularities. On the other hand, if close alignment is needed, a smooth flange will be necessary to get a tight seal with the thin gasket required for close tolerance assembly.

Even though the condition of the surfaces of the flanges may upset load calculations, many gasket users buy on specifications that contain clauses relating to compressibility or deflection under given loads. Thus, they often find that such load-deflection data does not work in actual practice—especially in the case of rubber compounds. Two other factors may also prove upsetting: the effect of gasket width on compression; and the relation of gasket thickness to the load.

The type of material used in the gasket determines when a change in gasket width will require a change in unit load to obtain a given amount of deflection. Rubber and other incompressible materials will flow. An increase in width acts to impede side flow and unit loads must be raised to obtain a given deflection, Fig. 1. Doubling the width of a typical 60 durometer neoprene gasket material steps up the required unit load from 400 psi for a ½ in. wide gasket to 770 psi for a 1 in. gasket.

At the other extreme, is a cork composition gasket stock that requires the same unit load to produce 25 percent compression regardless of gasket width. A cork and rubber material having a high loading of cork has about the same response as does the cork composition; whereas another cork and rubber stock having a lower proportion of cork more nearly approaches the behavior of the straight rubber.

The relationship of gasket thickness to load, Fig. 2, shows that when thickness is decreased, an increase in unit load may be necessary to maintain constant compression, assuming that width is constant. The amount of load increase, if any, will vary according to the type of gasket material chosen. In a truly compressible material such as cork composition, changes in gasket thickness involve virtually no load change to accomplish

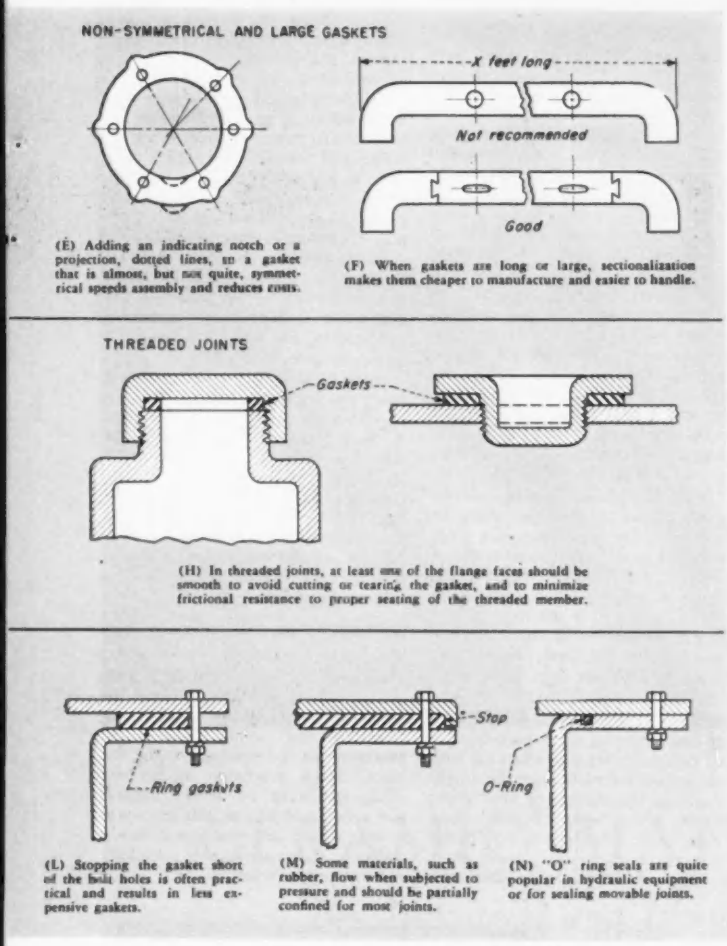

NON-SYMMETRICAL AND LARGE GASKETS
X feet long
Not recommended
Good
(E) Adding an indicating notch or a projection, dotted lines, to a gasket that is almost, but not quite, symmetrical speeds assembly and reduces costs.
(F) When gaskets are long or large, sectionalization makes them cheaper to manufacture and easier to handle.
THREADED JOINTS
Gaskets
(H) In threaded joints, at least one of the flange faces should be smooth to avoid cutting or tearing the gasket, and to minimize frictional resistance to proper seating of the threaded member.
Ring gaskets
Stop
O-Ring
(L) Stopping the gasket short of the bolt holes is often practical and results in less expensive gaskets.
(M) Some materials, such as rubber, flow when subjected to pressure and should be partially confined for most joints.
(N) "O" ring seals are quite popular in hydraulic equipment or for sealing movable joints.

Fig. 1—For incompressible materials, an increase in width will impede side flow and increase the unit loads required for a given deflection. Curves are for samples 6 in. long by ¼ in. thick between rough surfaces.

a given percentage deflection.

A straight rubber gasket stock, on the other hand, requires a sharply increased unit load when its thickness is decreased. As is to be expected, materials that are made by combining cork and rubber show an intermediate behavior.

The synthetic rubbers or combinations of synthetic rubber with asbestos, felt, cork, or other fibers are, of course, extremely important gasketing materials. The characteristics that are obtained naturally depend upon the type of rubber that is used.

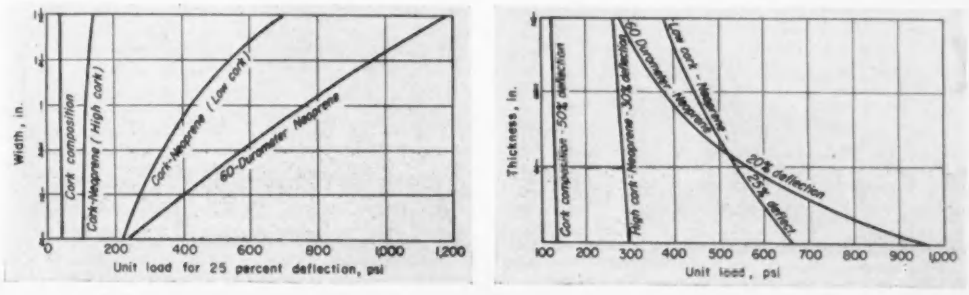
Neoprene-base compounds are classed as oil resistant rubbers. They have the special advantage of being highly resistant to strong sunlight or corona, but swell in gasoline and blends of aromatics.

Buna N (butadiene-acrylonitrile copolymer) base compounds in general have superior resistance to solvents and aromatic fuels. On the other hand, some oils may actually cause volume decrease in Buna N parts. Buna N is generally less likely to "freeze" or adhere itself to adjacent metal parts than are the other synthetic rubbers.

Buna S (butadiene-styrene copolymer) compounds provide good low temperature flexibility and other properties comparable to those of natural rubber, including poor resistance to oils. Thiokol compounds offer excellent resistance to many solvents but are likely to be inferior with respect to elasticity, particularly at elevated temperatures.

The ingenuity, manufacturing controls, and research of the individual compounders result in wide variations within a particular class. A 60 durometer Buna N compound offered by one compounder may not behave at all like a 60 durometer Buna N compound offered by another. There are general purpose compounds and highly specialized compounds. There are blends of different polymers, and there are compounds with high modulus

Fig. 2—Why an increase in unit load may be necessary to maintain constant compression when gasket thickness is increased and width remains constant. Samples 6 in. long by one in. wide between rough surfaces.



and compounds with low modulus. The designer who has a problem involving the proposed use of synthetic rubber is well advised to outline his problem in considerable detail to reputable compounders who know the special properties and the limitations of their particular products.

Since a great number of gasket applications require sealing against oil, designers should not overlook the fact that different oils affect synthetic rubbers differently. A group of investigators several years ago determined that the aniline point of an oil—the temperature at which dissolved aniline will separate or cloud when an oil-aniline mixture is cooled—is a firm index of the volume change which that oil will cause in a given synthetic rubber compound.

The relation between aniline point and volume change is shown in Fig 3. Here the same neoprene compound is immersed in six different oils. Although all oils are rated SAE 30, each has a different aniline point. Since the aniline points of five of these oils fall within a comparatively narrow range, the degree of swelling they produce is similarly restricted. The top curve is for an oil that, although rated SAE 30 like the others, has a low aniline point, indicating high swelling effect on rubber compounds. Consequently, it causes a greater volume increase.

The behavior of several synthetic rubber and cork-and-synthetic rubber compositions when immersed in one oil is illustrated in Fig. 4. These synthetic rubber compounds will maintain a similar behavior pattern when immersed in other oils. However, a negative change, shrinkage, may occur, with certain polymers or oils.

New Materials and Testing Techniques

The search for better gasketing materials and for precise design techniques that will supplant empirical methods of specification is, of course, a continuous process.

The need for flexibility and good aging qualities over a wide temperature range has stimulated the use of silicone and other new rubber-like materials. The silicones are particularly inert chemically and show little response to temperatures in the range of —100 to +500 F. A new synthetic rubber base on polyacrylic esters promises to be highly resistant to the deteriorating effects of high temperatures. The principal limitations of all such materials to date are high cost, and difficulty of compounding with organic fibers or fillers due to the high temperatures required for curing. Consequently, they currently are used for special purposes.

Problems of handling chemicals and solvents have focused attention on many new resins. Among the more important of these for gasket work are "Teflon" and "Kel-F", modified styrenes, polyethelene, and the prolific vinyl family. Here again, these are more or less limited to special applications in which the chemical properties of the materials are important.

To obtain new and improved characteristics in some of the older "tried-and-true" types of sheet packing, several companies are experimenting with fiber gasket materials made fluid-tight by adding the saturant or impregnant to the fibers before forming into sheets. This is usually called "beater saturation." Heretofore, most sheet packings of the paper or fiber type have been processed by adding a saturant to an absorbent type of base stock. The most popular saturant for general purpose gasketing has been a tanned glue-glycerin mix. Attempts to saturate a paper web with rubber or synthetic rubber latices have been only moderately successful. Beater saturation may permit increased use of latices and resins as saturants.

Tanned glue-glycerin has also been the most widely used binder for cork compositions. Several companies are now marketing or experimenting with cork compositions bonded with synthetic rubber latices. Indications are that these materials are lower in cost than the milled dry rubber and cork compounds; and are less permeable to liquids and gases.

Some of the most important work being done today in the gasket field is in connection with testing methods. A joint committee representing the American Society for Testing Materials and the Society of Automotive Engineers has been working for more than five years on standardized specifications covering the more important commercial types of gasket materials; this work, when published, will be a valuable contribution to gasket users.

Strain gages promise some exciting contributions to gasket technology. They permit measurement of gasket "kick-back" or stress relaxation without disturbing the test specimen by changes in bolt settings or other adjustments that would cause slight movement in the structure of the test piece. Stress relaxation studies are being conducted by several laboratories, but probably on long-term programs, so that data will appear slowly and only after considerable subsidiary and interpretive research.

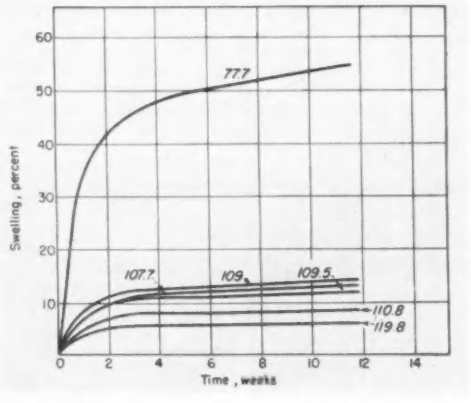


Fig. 3—Effect of various SAE 30 oils on swelling of black-loaded neoprene. Numbers on curves indicate analine point (deg C) which is a firm index of swelling that will occur.

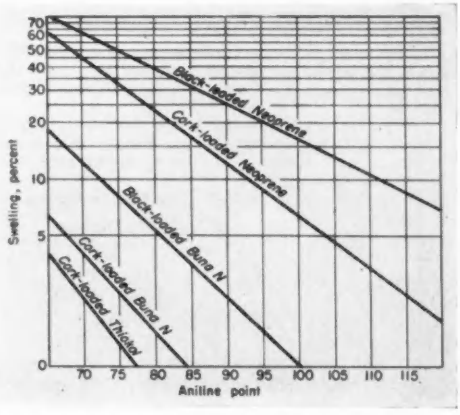


Fig. 4—How various synthetic rubbers react to oils having different analine points. Thus for any given application, analine point of oil should be considered for gasket material.

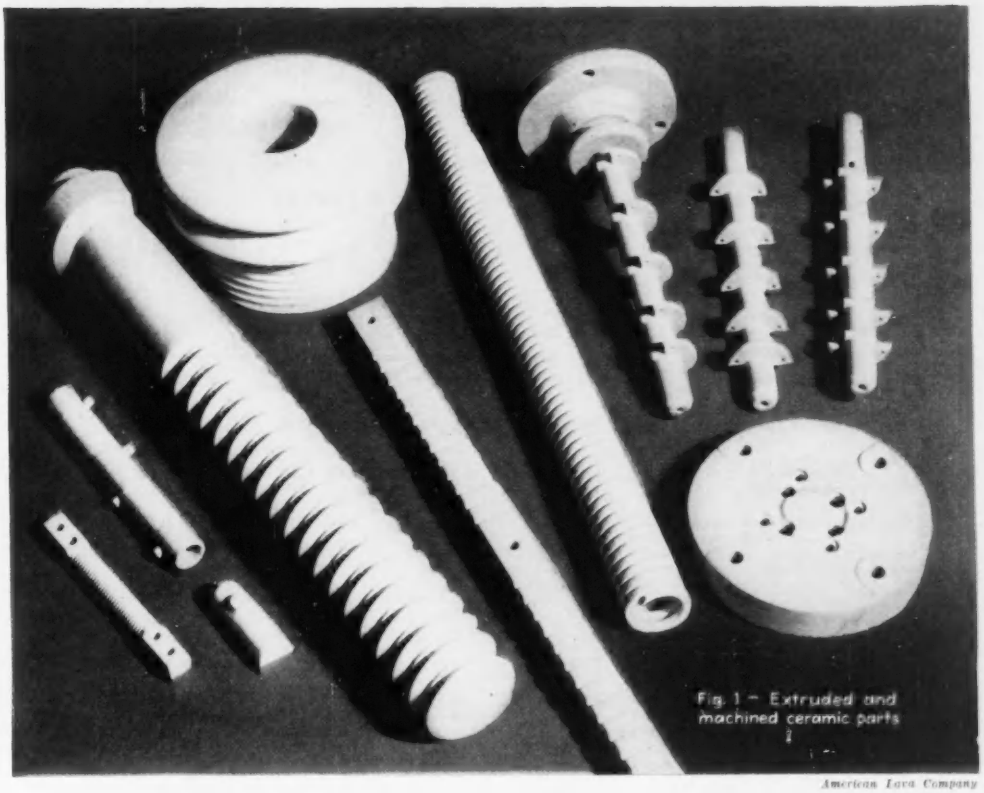


Fig. 1 – Extruded and machined ceramic parts

American Lava Company

CERAMIC MATERIALS

For Industrial and Electrical Use

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THE GROUP OF ENGINEERING MATERIALS designated as ceramics has, in recent years, been broadened to include all non-metallic and inorganic solids that have been heat-processed. Since this designation covers many porous and non-porous materials of widely varying compositions, the range of mechanical and electrical properties obtainable is sufficiently broad to meet the requirements of a great number of technical and industrial applications.

In general, ceramics are resistant to extremes of temperature. They are characterized by almost zero cold flow, low impact resistance and tensile strength, high compressive strength, and high modulus of elasticity. Apparent porosities vary from zero to more than 75 percent by volume; and apparent densities, from about 2 to 4 gm/cc, in an intermediate range between organic plastics and steel. Thermal conductivities range from 0.003 to 0.01 cgs units, and linear coefficients of expansion from 0.5 to 12 x 10^{-6} per degree centigrade. Ceramic materials retain their shape at high temperatures and can be accurately machined.

The electrical properties, including dielectric strength, dielectric loss, dielectric constant, and volume resistivity vary within wide limits. Most ceramic bodies withstand attack by all acids except hydrofluoric; some are immune to alkalis and super heated steam; and a few bodies have been made that are resistant to most types of chemical corrosion.

The wide range of properties of ceramic materials shown by Table I reflects the great variety of ceramic compositions:

WHITEWARES, including electrical, chemical refractory, and sanitary por-

Table 1—Properties and Applications of Typical Ceramic Bodies

	Material	Specific Gravity g/cc	Melting Point C	Softening Temp. C	Max. Safe Operating Temp. C	Thermal Conductivity g. cal x cm thick / cm² x sec x C	Thermal Shock Resistance
PURE OXIDES (FUSED)	Alumina (Al_2O_3)	3.2-4.0	2,000–2,050		1,400–1,450	0.007–0.0103	Excellent
	Beryllia (BeO)	3.0	2,520–2,570		2,400	0.02–0.036	Excellent
	Magnesia (MgO)	3.5–3.7	2,800		2,315–2,400	0.0069–0.014	Poor
	Thoria (ThO_2)	9.6–9.7	3,030–3,050		2,700	(low)	Poor
	Zirconia (ZrO_2)	5.6–6.1	2,700–2,720		2,200 (stabilized)	0.0049	Fair
POROUS AND NON-VITREOUS BODIES	Porous Alumina Bodies	2.4–2.5		1,650–1,800	1,300–1,600	0.004	Excellent
	Cordierites ($2MgO.2Al_2O_3.5SiO_2$)	1.6–2.3	1,425	1,250–1,400	1,050–1,250	0.0015–0.004	Excellent
	Lava (natural fired talc or pyrophillite)	2.3–2.8		1,475–1,600	1,100–1,200	0.003–0.005	Good
	Mullite ($3Al_2O_3.2SiO_2$)	2.1	1,790–1,835	1,650	1,350	0.003–0.004	Good
	Electrical Porcelain, low voltage	2.3–2.5	1,520	1,440–1,485	900–1,200	0.004–0.005	Fair
	Spinel ($MgO.Al_2O_3$)	3.5–3.6	1,915–2,135		1,700–1,900	0.005	Fair
	Silicon Carbide	3.2	2,200–2,240 (Dissoc.)		1,790	0.02–0.416	Good
VITRIFIED BODIES	Alumina Porcelain	3.1–3.9		1,750	1,350–1,500	0.006–0.05	Excellent
	Elect. Porcelain (high volt.)	2.3–2.5		1,300–1,485	1,000–1,200	0.0025–0.005	Fair
	Forsterite ($2MgO.SiO_2$)	2.8	1,885–1,910	1,440	1,000	0.008	
	Glasses	2.1–3.4		400–1,500	350–500	0.001–0.004	Poor to Good
	Glass-bonded Mica	2.8–3.5		450–500	300–400	0.0009–0.0014	Fair
	Rutile Bodies	3.9–7.2		1,350–1,640	1,000		
	Silica, Fused	2.2	1710		900–1,200	0.003–0.0046	Excellent
	Steatite, comm'l ($MgO.SiO_2$)	2.5–2.8		1,300–1,450	980–1,100	0.006	Fair
	Steatite, low loss ($MgO.SiO_2$)	2.6–2.8		1,300–1,450	980–1,100	0.005–0.006	Fair
	Titanate Bodies	3.5–8.9			800–1,000	0.008–0.01	Poor
	Zircon Porcelain	3.0–3.8		1,450	1,000–1,200	0.010–0.015	Good
	Chemical Porcelain	2.5				0.0034	Good
	Chemical Stoneware	2.2				0.0028	Poor to Fair

*pyrophyllite **talc

celains, are generally composed of feldspar, ball clays and kaolins, flint, and dolomite. Other types of whitewares include steatite, cordierite, mullite, sillimanite, titanates, and special porcelains consisting of clays and fluxes with additives of alumina, titanium dioxide or zircon.

CHEMICAL STONEWARES are vitrified products generally prepared from clay, feldspar, and silica.

IN REFRACTORIES the more commonly used materials are fireclay brick, consisting mostly of flint clays orkaolin; high-alumina brick; silica brick, made by bonding quartzite and hydrated lime; chrome-magnesite brick; zircon, forsterites, and mullites; carbides, nitrides, and borides; pure oxides such as alumina, beryllia, magnesia, thoria, titania, and zirconia; and sintered mixtures of metals and ceramics.

GLASS COMPOSITIONS, in addition to the ordinary soda-lime-silica types, include lead, borosilicate, flint, phosphate, and fluoride types; special glass compositions contain mica or certain oxides.

ELECTRICAL RESISTORS can be made from sintered oxides, sintered mixtures of oxides, clay, and graphite, or sintered mixtures of ceramic and metal powders. These are different compositions than the ordinary electrical porcelains.

REFRACTORY CEMENTS, mortars, and castables are mixtures of almost any refractory grog and either a clay mixture or an air-setting agent.

A discussion of all types of ceramic materials is, however, beyond the scope of this short survey, which will be limited to whitewares, special electrical ceramics, and high temperature bodies.

Whiteware Bodies

The technical whitewares may be conveniently divided into two groups of ceramic bodies, namely (1) vitrified materials and (2) porous and non-vitreous materials. In the first group are the electrical insulating ma-

(Exact value for each material depends on composition, processing, and measurement method)

Linear Coefficient of Thermal Expansion		Tensile Strength, 1,000 psi	Compressive Strength, 1,000 psi	Modulus of Rupture, 1,000 psi	Percent Water Absorption	Hardness, Mohs' Scale	Typical Applications
x 10^6	Range in C						
8.1-9.0	20-1250	35	200-400	48		9.0	Kilns, electric furnaces, heat and electrical insulators, vacuum tube spacers, thread guides.
9.2-9.4	20-1400	14	56-103	20.6		9.0	Laboratory refractories, vacuum tube spacers
14.3-15.0	20-1700					6.0	Kilns, electric furnaces, turbine combustion chambers, heat insulators, laboratory refractories
9.4-9.5	20-1400		105-220	17.9		7.0	Electric furnaces, laboratory refractories
6.5-11.0	20-1250	17.9	147-302	26.1		8.5 fused 6.7 sintered	Electric furnaces, rocket combustion chambers
2.2-5.1	20-100	0.7-3.0	11	10.0-10.4	12-18	9.0	Open hearth furnaces, kilns, spark plug cores, refractory cements.
1.0-2.0	25-300	1-5	20-70	1.5-11.0	5-15	6.0-7.5	Pyrometer tubes, heat insulators, thermocouple insulators, laboratory refractories.
2.9*							
10.7**	20-100	2.0-2.4	20	7-9	1-3	6.0	Experimental models.
3.5	20-100	2	10	6	10-15	6.0	Spark plug cores, glass tank covers, open hearth and electric furnace refractories.
3.0-4.5	20-100	1.0-3.5	30-50	6-8	0-2.5	6.5-8.5	Appliance insulators, thermocouple insulators, panel spacers.
9.0	20-1250	18.6	133-247			8.0 9.0-10.0	Refractories, abrasives, rocket combustion nozzles, laboratory equipment.
5.5-8.1	20-700	8-30	80-250	20-45	0	8.5-9.0	Spark plug cores.
3.7-5.5	20-100	2-8	40-80	6-18	0-0.5	7.0-8.5	Power line insulators, vacuum tube bases, panel spacers.
9.1	20-100	10	85	20	0 -0.05	7.5	Glass tank roofs, gas generators, vacuum tube bases.
3.5-12.0	20-300	4-10	50-180	7-18	0	4.5-6.0	
8.0-11.7	20-350	5-16	20-52	15-20	0.0-2.5	3.0-4.0	Electrical panel spacers
7.1-8.6	20-600	6.5-8.0	80-120	6-25	0.0-0.5	7.5-8.0	
0.5	20-1250	2.5-7.0	20-30		0	5.0-7.0	H-f insulation.
8.0-10.0	20-600	8.5-10.0	65-90	18-20	0.0-0.1	7.0-8.0	Power line insulators, appliance insulators vacuum tube spacers and bases, nozzle tips.
8.6-10.5	20-700	8-10	65-130	16-24	0.0-0.08	7.0-8.0	H-f insulation.
6-10	20-100	4-10	40-130	8-15	0	7.0-8.0	Capacitor dielectrics, piezoelectric transducers.
3.5-5.5	20-700	10-15	70-150	20-35	0.0-0.5	7.0-8.5	Power line insulators, appliance insulators, h-f insulators, spark plug cores, vacuum tube bases.
3.5-4.2	20-600	6-12	60-100	14		9.0	Laboratory equipment, chemical storage ware.
5.0	20-600	2.5	80	6.5		8.5	Laboratory equipment, chemical storage ware.

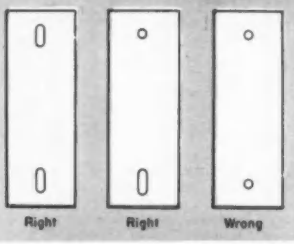
terials comprising the electrical porcelains, zircon porcelain, steatite, cordierite, and high- alumina bodies; chemical porcelains and stoneware; and thermal and mechanical whitewares of china or porcelain. In the second group are the porous electrical insulating materials, lava (block talc), pyrophillite, forsterite, titanate, and pure oxides; porous cordierite, mullite, and alumina refractories; and earthware for mechanical and chemical applications.

Most whitewares can be manufactured by the wet or dry processes similar to those used for electrical porcelain. Steatite, for example, is made in much the same manner except that in the dry-press process the finely powdered talc can be compressed without the addition of moisture. Dry-pressed parts can be made to highly accurate specifications on automatic machinery. Steatite bodies, made of powdered talc, clay, and alkaline earths, are characterized by high mechanical strength, low dielectric losses, rather high thermal expansion, and are economical in production. They can be formed by pressing, machining, extruding, slip casting, and, as shown by recent research, even by injection molding. Parts of complex shape are slip cast or cast and machined. Small plates like bushings, spacers, and similar forms are dry-pressed if the quantity warrants the cost of the die. Large plates like tube sockets and bearing plates are wet-pressed. Stand-off insulators, coil forms, and similar parts are extruded into either cylindrical or solid rods, Fig. 1, and then machined.

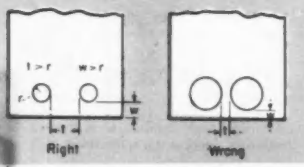
Where the required number of parts is too small to justify the expense of dies or where it is desired to make up test parts or experimental models for comparative tests, the use of lava is much more economical than steatite processed from powdered talc. Lava can be easily machined and after being fired to about 1,800 F has physical properties generally similar to those of steatite bodies.

Since the firing shrinkage of lava is small, it can be formed to excellent dimensional accuracy and is utilized for parts requiring critical tolerances, such as spacers in electron tubes. In such applications, the ease

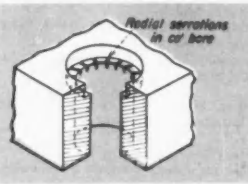
Table II—Design of Whiteware Parts



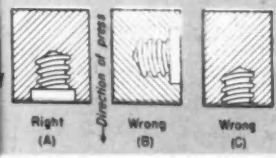
HOLE SHAPE. Since ceramic bodies shrink on firing, providing elongated holes insures ease of assembly. If only one hole is elongated, its length should be greater than the diameter by twice the amount of the tolerance between holes.



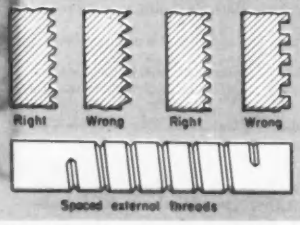
HOLE SPACING. Closely spaced holes, or holes that are near the edge of the part may cause cracking and require expensive dies. Walls should be at least half the diameter of the hole and have a thickness no less than 0.03 in. and preferably no less than 0.06 inches.



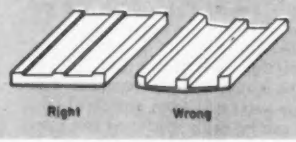
SERRATIONS. Where rivets are used to fasten ceramic to a metal part, serrations will absorb shock and prevent the part from being broken during riveting. Radial serrations on a countersunk hole in the ceramic piece provide a rugged construction for use with rivets or eyelets.



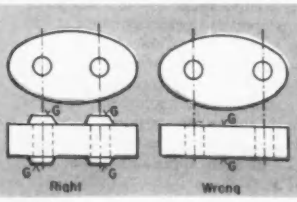
TAPPED HOLES. Tapped holes should be countersunk to reduce manufacturing losses, and tapped in the direction of press or extrusion movement, *A*, because holes in a perpendicular direction *B* have tendency to become elliptical.



THREAD TYPES. Screw threads should be rounded or filleted to avoid sharp edges. On external surfaces, spaced threads are a strong construction. For parts requiring fine threads, the extrusion process, rather than dry pressing, is recommended.



GROOVES. Excessively thin walls such as those resulting from the use of deep grooves tend to warp in firing. Where a section of a wall is too thick, use of a hole will provide better mass distribution. On extruded parts, wall thickness should be uniform when possible.



BOSSES. Using bosses on parts that must be ground flat decreases the grinding area and provides a support for the grinding operation. Tapers and radii should be specified on all ears, bosses, and depressions.

with which it can be degassed is also an advantage.

The firing ranges of clinoenstatite materials and other ceramic whitewares are small and care must be taken to insure a minimum of manufacturing losses. Low-loss porcelain, on the other hand, generally has a firing range wider than 200 F and is dense throughout that range. The zircon porcelains contain 50 percent or more of zircon by weight, fluxes, (usually consisting of double zirconium silicates of the alkaline-earth oxides), clay, and sometimes small additions of bentonite. These porcelains have high tensile strengths, low thermal expansions and good thermal shock characteristics. Loss factor is slightly lower than for steatite, except at high temperatures. Like other whitewares, zircon porcelain is too hard to permit any appreciable amount of shaping after firing, although lapping and grinding can be performed with the aid of hard alumina, silicon carbide, or diamond dust.

A group of materials having even lower thermal expansion are the cordierite bodies. The commercial product is porous, because the short firing range required to produce a vitrified mass of cordierite crystal from talc and clay makes mass production of a non-porous material rather difficult. Cordierite ceramics can be made to close dimensions and are used in electrical and radio applications like coil forms and wire supports where dimensional stability with changing temperature is important. Their electrical resistivity is high at elevated temperatures, but both the dielectric and mechanical properties are surpassed by steatite bodies. Large quantities of cordierite parts are used for pyrometer lead insulators and industrial burner tips and nozzles.

The refractory oxides of aluminum, magnesium, beryllium, zirconium, or thorium can be compacted in either a pure state or mixed with clay or talc and alkaline earth fluxes to make bodies ranging from porous to dense, depending on processing. These whitewares can be operated continuously at high temperatures. The porous bodies are mechanically weak but the dense ones exhibit superior mechanical and thermal qualities. Since they must be fired at temperatures above 2,700 F they are costly to produce, but they have excellent physical properties. Dense high-alumina bodies, for example, have been satisfactory for spark plugs in aircraft, where the insulating material must withstand severe mechanical and thermal shock and must have high dielectric strength and volume resistivity. Pure sintered

alumina formed by pressing or extrusion has also been used successfully in this application.

In addition, the extreme hardness of dense oxides has been utilized in parts requiring high abrasion resistance. An example of this is the alumina and titania thread guides used in the textile industry. Typical shapes, Fig. 2, include eyelets, tension tubes and rods, winders, and coning guides.

Instead of being glazed, such parts are given a high surface polish so that slow, gradual wear merely exposes new surfaces of the same hard material.

Another category of the technical whiteware materials is chemical ware. The high resistance of ceramics to chemical corrosion, even at high temperatures, is utilized in chemical stoneware and porcelains.

Chemical porcelain bodies are similar in composition to electrical porcelain, and are usually fired to zero porosity. In general, thermal conductivity is higher and thermal expansion lower than for stoneware, and thermal shock characteristics are good. Recent developments have resulted in chemical porcelain in large shapes suitable for industrial-scale equipment. Chemical porcelains are also used in the form of industrial ware for production and handling of certain food and pharmaceutical products. Applications of chemical stoneware include storage tanks, distillation towers, acid elevators, and pipes and valves.

Design Limitations of Whiteware Parts

Whether the ceramic part is extruded, pressed, or cast, costs may often be kept at a low level if the piece is designed so that it does not require machining after firing. Since it is generally not economical to rebore holes in hard, fired ceramic parts, it is good practice to elongate one or both of the holes, Table II. Also, since the firing shrinkage on the axis of pressing or extrusion is slightly different from shrinkage perpendicular to that axis, round holes will sometimes become elliptical after firing. This ellipticity, however, is generally less than 3 percent on solid stock and even less on tubing. The tolerances on holes that are not perfect circles would be applied to the minor axis only.

If tapped holes are necessary the threads should be as coarse as possible to reduce shrinkage error and to avoid crumbling of threads. Size 6-32 thread is about the smallest that will ordinarily give satisfactory results. Tapped holes should be slightly countersunk and should preferably have a minimum of six threads and a maximum of twelve threads. The depth of a shallow hole below that required for the screw should be at least three threads plus the original drill tip. Metal screws having close tolerances are preferable for providing the most satisfactory fit.

Grooves and slots of ceramic parts should be as shallow as is practical and the use of fillets on all internal edges will increase the strength of the part. Likewise, all sharp edges which tend to chip during manufacturing and handling should have a slight radius or bevel. Any modifications of the edges are usually incorporated in the die because machining after firing adds to the cost.

If pressed parts are to be mounted on a flat surface, they should be designed so that they can be ground flat after firing. Insertion of a resilient material between the ceramic part and other parts in a rigid assembly will aid in preventing breakage of the ceramic material due to differential expansion.

The tolerances on whiteware parts are affected materially by manufacturing methods. The shrinkage on steatite parts, for example, ranges from as low as 7 percent on dry press materials to as high as 20 percent on extruded parts. This shrinkage is affected by the normal variations in chemical composition of the raw materials, the moisture content, die pressure, fill of the die, drying and firing temperatures, and techniques of glazing. Additional factors affecting tolerances are the wear of machine tools and the differential shrinkage of ceramic parts after firing. The size of the part, of course, is another factor. These limitations have been accounted for in the "General Standards for Steatites and Other Electronic Grades of Ceramics" adopted by the Steatite Research Council, and the tolerances permitted are outlined very briefly in Table III.

In general, dry-press parts can be made without a finishing process to closer tolerances than wet-pressed or cast parts. Tolerances closer than those specified in Table III, can be obtained, but may involve grinding or selective gaging. An accuracy of about ±0.0004 in. can be obtained by simple plane or cylindrical grinding.[1] All flat plates and warpable surfaces should have an allowable camber unless the surface is to be ground flat. For details of camber tolerances, see the Standards published by the American Standards Assn., C75.2-1943.

The recommended system of deci-

[1] For detailed tolerance recommendations for electrical porcelain parts, see PRODUCT ENGINEERING, Nov., 1949, p. 90.

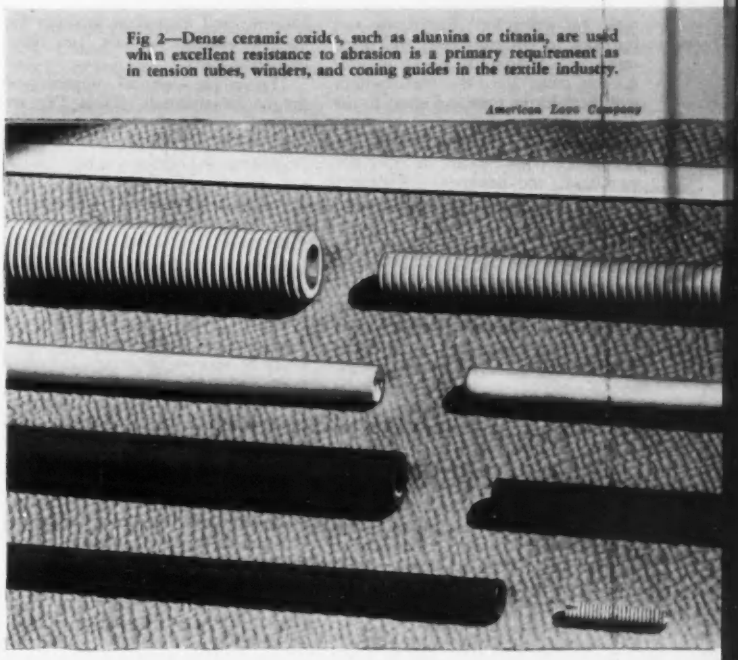


Fig 2—Dense ceramic oxides, such as alumina or titania, are used when excellent resistance to abrasion is a primary requirement as in tension tubes, winders, and coning guides in the textile industry.

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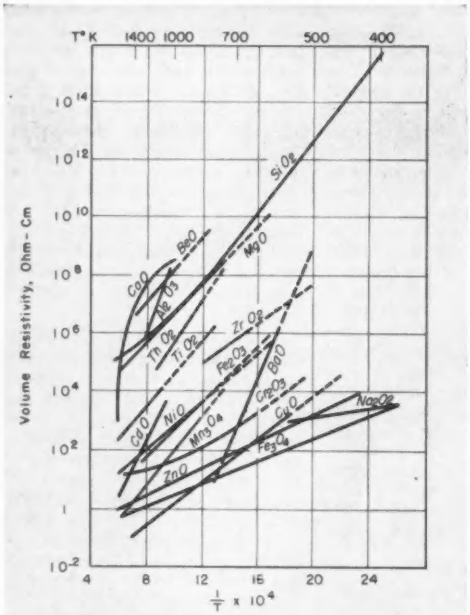

Fig 3—Resistivity-temperature characteristics of pure oxides. Since, however, valves vary widely with measurement techniques, these data are only approximate.

Table III—Tolerances for Electronic Grade Ceramics

DIMENSION	TOLERANCE
Critical Dimensions	
(Decimals)	
Thicknesses greater than 1 in.	not less than ± 3 percent
Thicknesses 1 in. or less:	
unglazed surfaces (general)	± 1%, but not less than ± 0.005 in.; min. of ± 0.010 in. on thickness dimensions
all glazed surfaces	± 1% + 0.010 in.
cylindrical shapes(unglazed)	± 1%, but not less than ± 0.005 in.; min. of ± 0.010 in. on nominal wall thickness dimensions
Non-Critical Dimensions	Same tolerances as critical dimensions plus 1/64 in.
(Fractions)	
Hole centers:	
spacings less than 0.500 in.	± 0.005 in.
spacings 0.500in. and greater	± 1 percent
Hole diameters (unglazed):	
less than 0.500 in.	± 0.005 in.
0.500 in. and greater	± 1 percent
Hole diameters (glazed):	
less than 0.600 in.	± 0.012 in.
0.600 in. and greater	± 2 percent (For holes that are not perfect circles, tolerances apply to minor axis)
Ellipticity of Tubes	
For wall thickness greater than 10% of O.D.	$\frac{\text{long dia.}}{\text{short dia.}}$ = 1.02 or less
For wall thickness = 7% to 10% of O.D.	$\frac{\text{long dia.}}{\text{short dia.}}$ = 1.03 or less
Pillar insulators	
top-bottom parallelism and perpendicularity to center axis	± 2 deg.

mals for important dimensions and fractions for arbitrary ones will often result in a substantial saving of production costs, since the manufacturer will then devote time and effort to the dimensioning problems according to their relative importance. In addition, if any of the dimensions are especially significant, the designer can place a separate list on the blueprint, headed "Important Dimensions."

Ceramics for Special Electrical Applications

In addition to the use of whitewares and glass for electrical insulation for power lines, switching devices, and electrical apparatus, other ceramic materials have been employed in recent years for electrical applications. Materials of high dielectric constant are utilized in capacitors with a considerable saving of space; piezoelectric ceramics are used in electromechanical transducers; sintered oxides are employed in voltage surge absorbers, bolometers, pyrometers, temperature compensators, and time delay devices; sintered mixtures of metals and ceramics can furnish resistors of zero temperature coefficient; ferrites are used in ferromagnetic cores for r-f transformers; and mica-glass products are used in panels, supports, and other insulating parts.

The unique electrical properties of titanium compounds, Table IV, are utilized extensively in capacitor dielectric materials, particularly for high-frequency applications where small size, low loss, and temperature compensation are important. Since rutile, unlike most minerals, has a negative temperature coefficient of dielectric constant, it can be sintered in combination with other materials to produce bodies with a temperature coefficient near zero.

In general, the temperature coefficient is negative for materials having high dielectric constants and is positive for materials for low dielectric constant. Stability of dielectric constant with changing temperature is extremely important for stability of tuned radio circuits where a slight alteration of the capacitance will cause unwanted shifts in output frequency.

Titanates of barium, calcium, strontium, magnesium, zinc, and tin provide commercial materials with a wide range of dielectric constants from about 15 to 6,000, depending on composition. Experimental samples of barium-strontium titanates, when operated at carefully controlled temperatures, have exhibited dielectric constants as high as 20,000.

An example of how ceramic materials of a high dielectric constant have been utilized in miniature capacitors for use in radio and electronic circuits are small condensers, made in ratings up to 0.01 or 2x0.004 mfd.; they consist of a half-dime or dime-sized ceramic plate with silvered electrodes fired on both sides. Leads are soldered to the silver, and the capacitors are coated with a tough, moisture-resistant insulating resin. Other types of commercially available ceramic capacitors are made in tubular form. In addition to their space-saving advantages, these units can be obtained in a wide range of resistance-temperature characteristics for use as trimmer condensers in temperature-compensated circuits. Other important application for certain ceramic materials are piezoelectric units for microphone and phonograph pickups.

The electrical properties of ceramics have also been utilized in measurement and control instruments where materials having a high negative temperature coefficient of resistance are

Table IV—Typical Electrical Properties of Ceramic Bodies

Material	Dielectric Strength volts/mil	Dielectric Constant at 1 mc	Power Factor at 1 mc	Loss Factor*** at 1 mc	Volume Resistivity in ohm-cm		Te Value* C
					20 C	500 C	
Alumina (Porous)	~50	5.5–5.6	0.002–0.0025	0.0011–0.014	10^{10}–10^{14}	10^{8}–10^{9}	700–835
(Sintered)	160–1,100	7.3–11.0	0.001–0.002	0.0073–0.022	10^{14}–10^{15}	10^{8}	>700
Cordierite (Porous)	40–150	4.5–5.5	0.003–0.01	0.0135–0.055	10^{12}–10^{15}	10^{8}–10^{9}	500–780
(Vitreous)	~95	4.1–5.4	0.012–0.45	0.049–2.43	10^{12}–10^{13}	10^{8}–10^{7}	500–700
Fosterite	240	6.2	0.0004	0.0025	10^{14}	10^{10}	<1000
Glasses	350–2000	4.0–9.9	0.01–0.0005	0.0045–0.04	10^{9}–10^{18}		200–360
Glass-bonded Mica	50–440	6.4–9.2	0.0002–0.0035	0.0014–0.0322	10^{12}–10^{15}		300
Electrical Porcelain							
Low Voltage	40–200	5.6–7.0	0.003–0.02	0.0168–0.14	10^{12}–10^{14}	10^{8}–10^{8}	300–500
High Voltage	150–400	5.5–7.0	0.006–0.01	0.033–0.07	10^{10}–10^{14}	10^{8}–10^{8}	300–500
Alumina Porcelain	400–700	7.3–11.0	0.001–0.002	0.0073–0.022	10^{14}–10^{15}		700
Mullite Porcelain	250–400	6.2–7.0	0.004–0.005	0.025–0.034	10^{14}–10^{15}		500–650
Zircon Porcelain	225–350	5.2–10.5	0.0002–0.002	0.001–0.021	10^{15}–10^{15}	10^{8}–10^{9}	700
Lava (Talc)	50–100	5.6	0.0008	0.0045	10^{14}	10^{8}	620
Silica (Fused)	100–400	3.2–4.2	0.0002–0.0023	0.0006–0.01	10^{15}–10^{18}	10^{7}	700–900
Steatite							
Commercial Grade	200–240	5.8–6.0	0.0012–0.0035	0.0695–0.0210	10^{13}–10^{15}	10^{8}–10^{9}	500–700
High-frequency Grade	200–350	5.7–6.3	0.0002–0.0035	0.0014–0.022	10^{14}–10^{15}	10^{8}–10^{10}	400–1000
Titanate Bodies	50–500	15–5000**	0.0002–0.05	0.003–250	10^{9}–10^{15}		200–400
Rutile Bodies	85–200	14–100	0.0002–0.005	0.0028–0.50	10^{12}		~550

*Temperature at which volume resistivity is 10^{8} ohm-cm.

**Dielectric constants as high as 20,000 have been obtained with experimental titanate bodies.

***According to Joint Army-Navy Specification, JAN-1-10, Grade "L" materials are graded according to loss factor not to exceed these values at 1 mc after immersion:

Class	L-1	L-2	L-3	L-4	L-5	L-6
Loss factor	0.150	0.070	0.035	0.016	0.008	0.004

required. Typical thermistor materials are sintered mixtures of the oxides of nickel, manganese, and cobalt. Unlike many other semiconductors, the electrical characteristics of these materials are not extremely sensitive to small changes in composition or to impurity content. Temperature coefficients of resistance for commercially available thermistors range from —3.0 to 4.6 percent per deg. C. The temperature dependence of resistivity for thermistor materials is utilized in measuring devices like bolometers, u-h-f power meters, gas pressure gages, flow meters; and various control devices. Thermistors are made in bead, rod, and disk shapes.

Other types of sintered semiconducting materials have special electrical applications. Work reported by Geller at the National Bureau of Standards has shown that sintered metallic-oxide rods of the Nernst filament type can be used as heating elements to operate at temperatures higher than those ordinarily attained by platinum elements in electric furnaces. Where the temperature coefficient of resistivity of the ceramic heating rod is high, it can first be heated by an external wire coil to the point where it becomes electrically conductive, and the furnace is then operated at high temperatures by passing current through the ceramic rod itself.

Most ceramic materials have a high temperature coefficient of resistance, Fig. 3. Electrical resistors with a zero temperature coefficient have been developed for use in electronic equipments requiring high stability under conditions of changing temperature; they consist of sintered mixtures of conducting, semiconducting, and insulating components. Such resistors are a development of H. H. Hausner at New York University. One body having a temperature coefficient from —25 to 200 C consists of 72 percent ZrO_2, 23 percent talc, and 5 percent graphite. These pulverized materials are dry-mixed, compacted at 10 psi, and sintered at 1,000 C for three hours in an atmosphere of nitrogen. Samples of the resulting material have a resistivity of about 16-ohm-cm. By varying the proportions of the mixture, the particle sizes, and the sintering temperature the resistivities of the resistors can be varied from less than 1 ohm-cm to about 10^{7} ohm-cm, and the temperature coefficients can be made positive, zero, or negative. Sintered mixtures of powdered metals and insulators can also be made with resistivities in the semiconductor range.

Among other ceramic materials with unique electrical properties are the high-permeability ferrites for induction cores. These materials are used instead of powdered iron for radio-frequency transformer cores for reduction of eddy-current losses in both receiver and transmitter circuits. Typical applications are cores for deflection yokes in television receivers and band-pass coils for carrier-wave telephone. The complex metallic oxides can be fabricated into parts like other ceramic materials by pressing, extruding, or casting, and can be formed into suitable shapes which can be used in specialized applications at frequencies as low as 60 cycles. Initial permeabilities of some ferrites are of the order of 1,000. The compositions are generally represented by the formula $MoFe_2O_3$, where M is a bivalent metal like Cu, Fe, Mg, Mn, Ni, or Zn. Examples are Ferroxcube (North American Philips Company, Inc.), Vectolite permanent magnets (General Electric Co.), and Ferramic (General Ceramic and Steatite Corporation).

Stresses In Rotating Disks Of Nonuniform Thickness

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Simple method for calculating stresses in rotating disks based on rearranging fundamental stress relations in a form convenient for step-by-step calculation.

EVER SINCE THE DEVELOPMENT of the steam turbine, the problem of stresses in rotating disks has been an important one and several methods have been developed for solving it. The main advantages of the present method are simplicity and accuracy, and that it is largely self checking. Furthermore, the procedure can be as conveniently applied to a solid disk as to one with a central hole.

The thickness of the disk need not be a mathematically expressible function of disk radius. In applying the method, the given disk is approximated by a number of constant thickness elements as shown in Fig. 1. The stresses corresponding to two trial solutions are then calculated and superimposed in such a way that the required conditions at the inner and outer edges are satisfied.

Nomenclature

γ = density (for steel, 0.283), lb/in.^{3}
ω = angular velocity, rad/sec
g = acceleration of gravity, 386 in./sec^2
r = radius, in.
Δr = radial thickness of any element
μ = Poisson's ratio (for steel, 0.3)
h_n = uniform thickness of nth element, in.
h^* = true local thickness of actual tapered disk, in.
σ_r = radial stress in stepped disk, psi
σ_t = tangential stress in stepped disk, psi
σ_r^* = radial stress in actual disk, psi
σ_t^* = tangential stress in actual disk, psi

Subscripts

i = inner edge of any element
o = outer edge of any element
a = inner edge, or center, of disk
b = outer edge of disk
$n, n+1$ = any two consecutive elements

In discussing the theory and presenting the basic derivations that follow, other symbols will be introduced and defined as required.

CALCULATION OF COEFFICIENTS. The first quantity required for the analysis is the constant

$$N = \gamma \omega^2 / g \tag{1}$$

After subdividing the disk into a number of annular elements of constant thickness, the following coefficients are calculated for each element.

$$x = \Delta r / r_o \tag{2A}$$

$$\zeta = \left(1 - \frac{x}{2}\right) x \tag{2B}$$

$$\beta_r = 1 - \frac{1-\mu}{2} \zeta \tag{2C}$$

$$\beta_t = \mu + \frac{1-\mu}{2} \zeta \tag{2D}$$

$$L_r = \beta_r N r_o^2 \tag{2E}$$

$$L_t = \beta_t N r_o^2 \tag{2F}$$

Also, for each joint between adjacent elements, the following coefficient is computed.

$$\delta = (h_n / h_{n+1}) - 1 \tag{3}$$

CALCULATION OF STRESSES. The change in the radial and tangential stresses from the inner to the outer edge of any element can be calculated from known or assumed values at the inner edge as follows:

$$D = \sigma_{to} - \sigma_{ro} \tag{4A}$$

$$\Delta\sigma_r = (D - L_t)\zeta \tag{4B}$$

$$\Delta\sigma_t = -(D + L_r)\zeta \tag{4C}$$

The stresses at the outer edge are then simply

$$\sigma_{ro} = \sigma_{ri} + \Delta\sigma_r \tag{5A}$$

$$\sigma_{to} = \sigma_{ti} + \Delta\sigma_t \tag{5B}$$

Similarly, the changes in proceeding across the joint to the next element are

$$\Delta\sigma_r' = \delta\, \sigma_{ro} \tag{6A}$$

$$\Delta\sigma_t' = \mu\, \Delta\sigma_r' \tag{6B}$$

Consequently, the stresses at the inner edge of the next element are

$$(\sigma_{ri})_{n+1} = (\sigma_{ro})_n + \Delta\sigma_r' \tag{7A}$$

$$(\sigma_{ti})_{n+1} = (\sigma_{to})_n + \Delta\sigma_t' \tag{7B}$$

By applying the foregoing procedure successively from the innermost element outward, the stresses corresponding to any values initially assumed at the center or at the inner edge of the disk can be found at every other point.

Table I—Particular and Complementary Solutions for Given Conditions at Inner Edge or at Center

Key: X = an arbitrary trial value; Y = an arbitrary value different from zero

Condition at Inner Edge or Center	Assumed Values at Inner Edge or Center	
	Particular Solution	Complementary Solution
True Radial Stress	$\sigma_{ra}' = (h_a/h_a^*)\,\sigma_{ra}^*$	$\sigma_{ra}'' = 0$
σ_{ra}^* Given	$\sigma_{ta}' = X$	$\sigma_{ta}'' = Y$
Solid Disk, No Center Hole	$\sigma_{ra}' = X$	$\sigma_{ra}'' = Y$
	$\sigma_{ta}' = \sigma_{ra}'$	$\sigma_{ta}'' = \sigma_{ra}''$

Superposition of Trial Solutions

To satisfy the given conditions at the inner and outer edges of the disk, it is necessary to calculate and superimpose two trial solutions, as follows:

Step 1. A particular solution, denoted by a single prime mark ($'$), is calculated as explained in the preceding discussion, starting with assumed values at the inner edge of the disk in accordance with Table I.

Step 2. A complementary solution, denoted by a double prime mark ($''$), is calculated in the same way except that the quantities L_r and L_t are made zero in Eqs (4B) and (4C).

Step 3. The final solution is found by superimposing the particular and

complementary solutions according to the relations,

$$\sigma_r = \sigma_r' + C\,\sigma_r'' \quad (8A)$$
$$\sigma_t = \sigma_t' + C\,\sigma_t'' \quad (8B)$$

where the constant C is calculated from the formula

$$C = \frac{(h_b^*/h_b)\,\sigma_{rb}^* - \sigma_{rb}'}{\sigma_{rb}''} \quad (8C)$$

Employing the final values so obtained for the stresses at the inner edge, a separate calculation can then be made using the same procedure as for Step 1. The result should check the values obtained by superposition in Step 3, thus providing an independent check of the final answer.

The results obtained in this way for σ_r and σ_t involve abrupt changes across the joints between adjacent elements of the stepped disk. The corresponding true stresses σ_r^* and σ_t^* in the original smoothly contoured disk are finally obtained from the relations

$$\sigma_r^* = (h/h^*)\,\sigma_r \quad (9A)$$
$$\sigma_t^* = \mu\,\sigma_r^* + (\sigma_t - \mu\,\sigma_r) \quad (9B)$$

where δ_r and δ_t must both be taken for the same element that may, however, be either the one on the inside or the one on the outside of the joint in question.

SAMPLE PROBLEM. Calculate the stresses in the disk shown in Fig. 1 at 6,000 rpm with a load of 15,000 psi at the outer-edge.

The steps leading to the solution of this problem are summarized in the accompanying tables.

1. In Table II are given dimensions of the disk elements and values of the various coefficients.

2. In Table III is shown the particular solution for an assumed stress

$$\sum \sigma_{ra}' = \sigma_{ta}' = 12{,}000 \text{ psi}$$

at the center of the disk.

3. In Table IV is shown the complementary solution for an assumed stress

$$\sigma_{ra}'' = \sigma_{ta}'' = 1{,}000 \text{ psi}$$

at the center of the disk.

4. The constant C for a true radial stress

$$\sigma_{rb}^* = 15{,}000 \text{ psi}$$

at the outer edge is found from Eq (8C) to have the value 3.206.

5. The stresses obtained by superimposing the particular and complementary solutions in accordance with Eqs (8A) and (8B) are summarized in Table V.

6. The final true stresses in the smooth disk, according to Eqs (9A) and (9B) are listed in Table VI.

The disk in the present example is based on the exact analytical solution

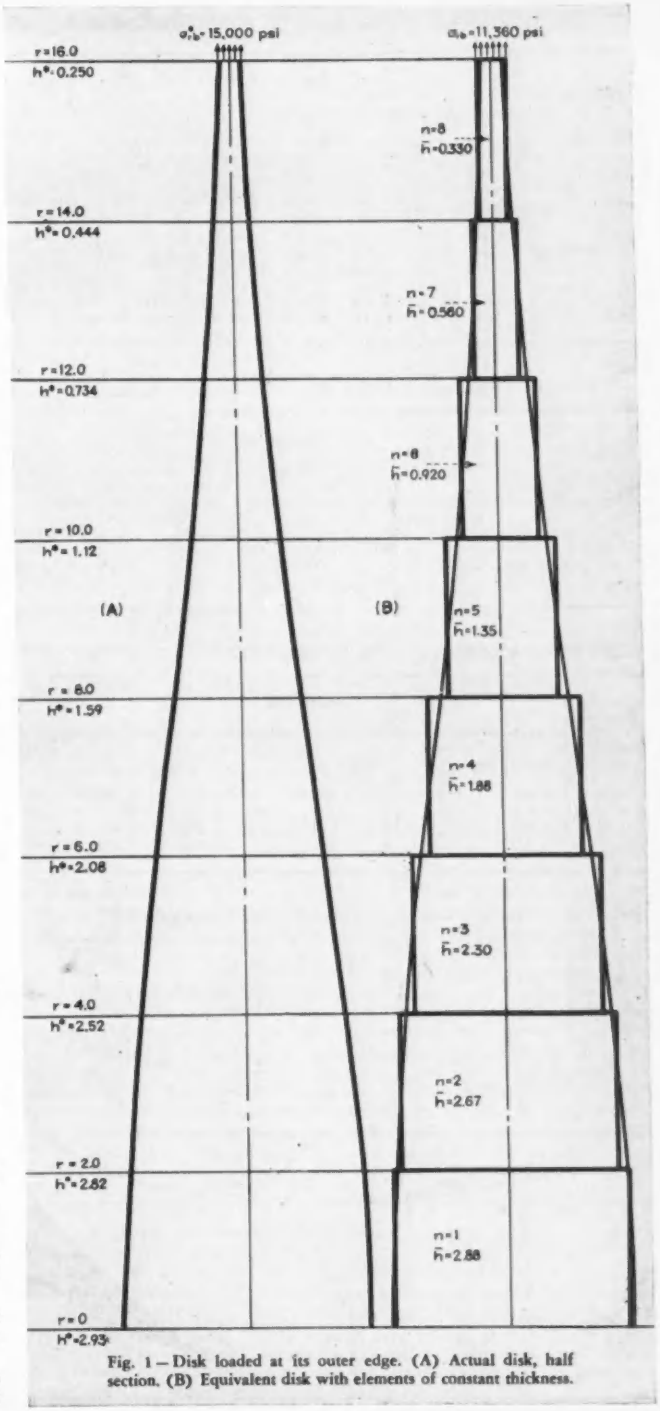


Fig. 1 — Disk loaded at its outer edge. (A) Actual disk, half section. (B) Equivalent disk with elements of constant thickness.

Table II—Elements of Disk Shown in Fig. 1 and Coefficients

Symbol	Units	Element Number, n							
		1	2	3	4	5	6	7	8
r_o	in.	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0
x	in.	1.0	0.50	0.333	0.250	0.200	0.167	0.143	0.125
ζ		0.500	0.375	0.277	0.219	0.180	0.153	0.133	0.117
β_r		0.825	0.869	0.903	0.923	0.937	0.947	0.954	0.959
β_t		0.475	0.431	0.397	0.377	0.363	0.354	0.346	0.341
L_r	lb in.^{2}	952	4,010	9,380	17,050	27,000	39,300	53,900	70,900
L_t	lb in.^{2}	548	1,990	4,120	6,950	10,470	14,690	19,600	25,200
h	in.	2.88	2.67	2.30	1.88	1.35	0.920	0.560	0.330
δ		0.078	0.161	0.224	0.393	0.468	0.643	0.697	
h_o*	in.	2.82	2.52	2.08	1.59	1.12	0.734	0.444	0.250

Table III—Particular Solution Where $\sigma_{ra}' = \sigma_{ta}' =$ 12,000 psi

Symbol	Element Number, n							
	1	2	3	4	5	6	7	8
σ_{ri}'	12,000	12,420	12,490	11,920	11,310	9,410	5,760	−1,730
σ_{ro}'	11,520	10,760	9,740	8,120	6,410	3,510	−1,020	−9,190
σ_{ti}'	12,000	12,000	11,930	11,600	11,110	10,160	8,470	5,300
σ_{to}'	11,730	11,410	10,940	10,148	9,260	7,800	5,510	1,530

Table IV—Complementary Solution, Where $\sigma_{ra}'' = \sigma_{ta}'' =$ 1,000 psi

Symbol	Element Number, n							
	1	2	3	4	5	6	7	8
σ_{ri}''	1,000	1,080	1,230	1,460	1,960	2,730	4,250	6,800
σ_{ro}''	1,000	1,060	1,190	1,400	1,860	2,590	4,010	6,410
σ_{ti}''	1,000	1,020	1,100	1,210	1,430	1,790	2,430	3,510
σ_{to}''	1,000	1,040	1,130	1,270	1,530	1,930	2,670	3,890

Table V—Superposition of Trial Solutions

Symbol	Element Number, n							
	1	2	3	4	5	6	7	8
σ_{ri}	15,210	15,880	16,430	16,590	17,580	18,170	19,370	20,070
σ_{ro}	14,730	14,150	13,560	12,620	12,370	11,810	11,830	11,360
σ_{ti}	15,210	15,280	15,440	15,490	15,690	15,890	16,260	16,550
σ_{to}	14,940	14,760	14,570	14,210	14,150	13,990	14,070	14,010

Table VI—Final True Stresses

Symbol	Element Number, n							
	1	2	3	4	5	6	7	8
σ_{ri}*	14,950	15,010	14,990	15,020	14,970	14,920	14,870	15,050
σ_{ro}*	15,020	14,980	15,000	14,960	14,910	14,900	15,050	15,000
σ_{ti}*	15,140	15,030	15,010	15,020	14,900	14,920	14,910	15,010
σ_{to}*	15,030	15,010	15,000	14,910	14,920	14,920	15,040	15,100

for disks of constant stress, and is designed for a constant stress of 15,000 psi at 6,000 rpm. The result obtained by the present method of calculation is seen to differ from the exact theoretical value by less than 1 percent.

As an illustrative example of the method, it is suggested that the reader perform a check calculation for himself. At the center where the true stresses

$$\sigma_{ra}^* = \sigma_{ta}^* = 15{,}000 \text{ psi}$$

the corresponding stresses in the stepped disk are

$$\sigma_{ra} = \sigma_{ta} = 15{,}210 \text{ psi}$$

and this latter value should be used in beginning the check solution.

Derivations

The fundamental equations for the stresses in an annular element of uniform thickness can be written (see S. Timoshenko; Strength of Materials, Part II, D. Van Nostrand Company, New York, 1945, p 245)

$$\sigma_r = -\frac{3+\mu}{8} Nr^2 + A - \frac{B}{r^2} \quad (10A)$$

$$\sigma_t = -\frac{1+3\mu}{8} Nr^2 + A + \frac{B}{r^2} \quad (10B)$$

where N is defined by Eq (1), and A and B are constants of integration that are chosen to satisfy the required stress conditions at the inner edge of the element. The quantities A and B are constant over any one element but, in general, change in value from one element to another.

At the outer edge of the element, Eqs (10A) and (10B) become

$$\sigma_{ro} = -\frac{3+\mu}{8} Nr_o^2 + A - \frac{B}{r_o^2} \quad (11A)$$

$$\sigma_{to} = -\frac{1+3\mu}{8} Nr_o^2 + A + \frac{B}{r_o^2} \quad (11B)$$

Similarly, at the inner edge,

$$\sigma_{ri} = -\frac{3+\mu}{8} Nr_i^2 + A - \frac{B}{r_i^2} \quad (12A)$$

$$\sigma_{ti} = -\frac{1+3\mu}{8} Nr_i^2 + A + \frac{B}{r_i^2} \quad (12B)$$

Subtracting Eqs (12A) and (12B) from (11A) and (11B) respectively, the result may be arranged in the form

$$\Delta\sigma_r = \sigma_{ro} - \sigma_{ri} = -\frac{3+\mu}{8} Nr_o^2 \left(1 - \frac{r_i^2}{r_o^2}\right) + \frac{B}{r_i^2}\left(1 - \frac{r_i^2}{r_o^2}\right) \quad (13A)$$

$$\Delta\sigma_t = \sigma_{to} - \sigma_{ti} = -\frac{1+3\mu}{8} Nr_o^2 \left(1 - \frac{r_i^2}{r_o^2}\right) - \frac{B}{r_i^2}\left(1 - \frac{r_i^2}{r_o^2}\right) \quad (13B)$$

By subtracting Eq (12B) from (12A), the quantity A is eliminated and the result may be solved for B. Thus

$$\frac{B}{r_i^2} = \frac{\sigma_{ti} - \sigma_{ri}}{2} - \frac{1-\mu}{8} N r_i^2 \quad (14)$$

Substituting Eq (14) in Eqs (13A) and (13B), and regrouping terms, leads to

$$\Delta\sigma_r = \tfrac{1}{2}(\sigma_{ti} - \sigma_{ri})\left(1 - \frac{r_i^2}{r_o^2}\right) - \left[\frac{3+\mu}{8} + \frac{1-\mu}{8}\frac{r_i^2}{r_o^2}\right] N r_o^2 \left(1 - \frac{r_i^2}{r_o^2}\right) \quad (15A)$$

$$\Delta\sigma_t = -\tfrac{1}{2}(\sigma_{ti} - \sigma_{ri})\left(1 - \frac{r_i^2}{r_o^2}\right) - \left[\frac{1+3\mu}{8} - \frac{1-\mu}{8}\frac{r_i^2}{r_o^2}\right] N r_o^2 \left(1 - \frac{r_i^2}{r_o^2}\right) \quad (15B)$$

By introducing the notation of Eq (2A), these expressions reduce to

$$\Delta\sigma_r = \left(1 - \frac{x}{2}\right) x \times \left\{(\sigma_{ti} - \sigma_{ri}) - \left[1 - \frac{1-\mu}{2}\left(1 - \frac{x}{2}\right) x\right] N r_o^2 \right\} \quad (16A)$$

$$\Delta\sigma_t = \left(1 - \frac{x}{2}\right) x \times \left\{-(\sigma_{ti} - \sigma_{ri}) - \left[\mu + \frac{1-\mu}{2}\left(1 - \frac{x}{2}\right) x\right] N r_o^2 \right\} \quad (16B)$$

The Eqs (16A) and (16B) are finally simplified to the form shown in Eqs (4B) and (4C) by utilizing the notation defined by Eqs (2B), (2C), (2D), (2E), (2F) and (4A).

At the joint between adjacent elements the radial force acting outward on one element must equal the radial force acting inward on the other. Furthermore, the radial deflection of both elements must be the same at the joint. These two conditions are expressed by the relations

$$(\sigma_{ro}h)_n = (\sigma_{ri}h)_{n+1} \quad (17A)$$

$$(\sigma_{to} - \mu\sigma_{ro})_n = (\sigma_{ti} - \mu\sigma_{ri})_{n+1} \quad (17B)$$

From these equations, the stress increments across the joint are

$$\Delta\sigma_r' = \left(\frac{h_n}{h_{n+1}} - 1\right)(\sigma_{ro})_n \quad (18A)$$

$$\Delta\sigma_t' = \mu\,\Delta\,\sigma_r' \quad (18B)$$

This result leads to the definition of δ in Eq (3), whereupon Eqs (18A) and (18B) are seen to agree with Eqs (6A) and (6B). Also, Eqs (9A) and (9B) are merely a special case of Eqs (17A) and (17B).

Referring to Eqs (10A) and (10B), let a particular solution be written as

$$\sigma_r' = -\frac{3+\mu}{8} N r^2 + A' - \frac{B'}{r^2} \quad (19A)$$

$$\sigma_t' = -\frac{1+3\mu}{8} N r^2 + A' + \frac{B'}{r^2} \quad (19B)$$

The corresponding complementary function becomes

$$\sigma_r'' = A'' - \frac{B''}{r^2} \quad (20A)$$

$$\sigma_t'' = A'' + \frac{B''}{r^2} \quad (20B)$$

Substituting these expressions into Eqs (8A) and (8B), the results reduce to the form given in Eqs (10A) and (10B), provided

$$A = A' + C\,A'' \quad (21A)$$

$$B = B' + C\,B'' \quad (21B)$$

This result verifies the superposition principle expressed by Eqs (8A) and (8B), the importance of which has previously been emphasized.

Contour Mapping of Optical Surfaces With Light Waves

CONTOUR MAPS of precise optical surfaces, whose contour intervals are a small fraction of a wavelength of light, have been prepared by the National Bureau of Standards. Optical maps serve the same purpose as topographic maps, except that they measure surface irregularities in millionths of an inch. For example, optical flats, for calibrating precision gages must be flat and parallel within one five-millionth of an inch.

The new maps can check the accuracy of these surfaces. The maps are made by photographing interference patterns formed when light waves are reflected from the surfaces of a specimen and a standard reference of known shape. This is simple interferometry, and is common practice in precision measurement of optical surfaces.

Previously the surface being analyzed was placed close to and almost parallel with the standard surface, leaving a thin layer of air between. The fringes produced by the interference of monochromatic light reflected normally from these two surfaces gave a good indication of the quality of the surface. When proper adjustments were made, the fringes were one-half wavelength apart, relatively broad, and showed dark against a bright background. Gross irregularities in the surface caused these lines to bend, and their appearance is a fairly good measure of how smooth, the surface is. However, irregularities of several tenths of a wavelength can go undetected if they fall between two adjacent lines. Even smaller irregularities can be completely hidden within the broad dark bands.

Some improvement in the quality of the lines is obtained if both the standard and the unknown are covered with a uniformly thin coat of highly reflecting metal, such as silver or aluminum. This makes the lines thinner. The resulting narrow-line fringes are dark by reflected light or bright against a dark background with transmitted light. With modern methods of metal deposition and with smooth surfaces that are almost parallel to each other, fringes can be obtained whose widths are only one-fiftieth part of their separation. Deviations can be measured to better than 1/100 wavelength, but this does not reveal surface defects between the half-wavelength lines.

A method has now been worked out by which additional lines are placed between each of the half-wavelength lines. As many as 15 have been added thus reducing the spacing between lines to 1/30 wavelength, or 6 ten-millionths of an inch. This results in a much more complete map and brings out details of the surface not shown with the wider interval.

The position of interference lines can be changed by increasing or decreasing the optical separation of the two interferometer plates. This is done by inclosing the plates in an air-tight chamber and changing the air pressure in equal increments as determined by wave length of the light, gas in chamber and pressure differential.

A typical map prepared in this way has revealed patterns on a polished specimen arising from the particular stroke and polisher used in finishing. Although conventional half-wavelength photographs showed some irregularities, they did not give a complete picture of the surface. Seven additional fringes, clearly pointed out the circular character of the pattern. It was then possible to alter the polishing technique in order to obtain a smooth surface. These maps also reveal other irregularities such as those caused by small particles of polishing material. Thus polished surfaces can be controlled to a final accuracy limited only by the number of fringes that can be interpolated between two half-wavelength fringes.

Synchronizing Piston Movement In Hydraulic Cylinders

THE SEVEN CIRCUIT SKETCHES presented herewith depict various methods for causing two or more hydraulically operated pistons to extend and retract in perfect synchronism. Each circuit has been tried and proven. Yet, even with these tested methods at hand, the designer will find that piston synchronization is not a simple task. Many variables exist that tend to upset operation in unison. The variables to be watched are as follows:

(a) Packing Friction. Merely arranging a group of cylinders, having the same bore and stroke, in parallel rarely leads to synchronized operation. Friction caused by elements such as tight rod packing and tight piston rings slows movement of some pistons more than others. If the friction on one piston is great enough, it may not move at all until the other pistons have completed their strokes.

(b) Piston Leakage. If excessive leakage occurs around the piston of one cylinder in a group, or if each cylinder leaks a different amount, synchronization is hard to achieve. It is often desirable to add an O-ring to ring type pistons or to use pistons with cup type packing. Leakage is especially detrimental when equalizers are employed.

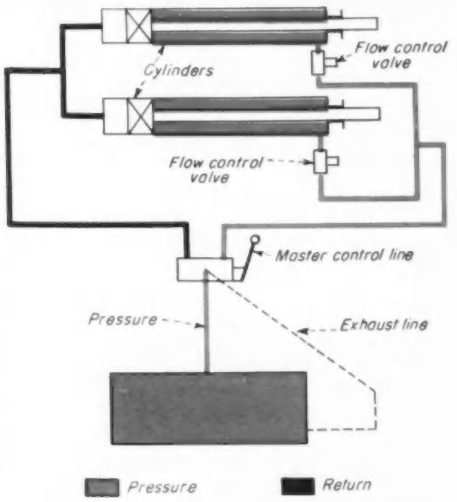
(c) Valve Leakage. Valves must have minimum leakage if circuit is to perform with any degree of success. After wear occurs in valves, new pistons should be installed.

(d) System Leaks. All external leaks must be eliminated. Pipe fittings must be tight and free from all leaks. Any leaky gaskets on valves or cylinders must be eliminated.

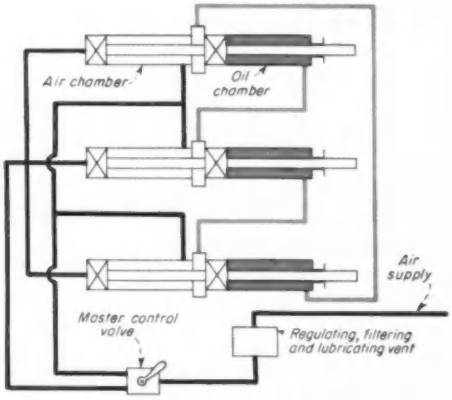
(e) Oil Cleanliness. Where valves with orifices are a governing factor, the oil cannot be contaminated. Minute particles can clog up the orifices on flow control valves, especially if they are set for very fine feed.

(f) Bore Size. Even though the nominal bore size of two cylinders are the same, it is difficult to make sure that the finished size of the cylinder tubes are identical. A few thousands difference in bore size will make a difference in the speed of piston travel, especially if equalizing or metering means are employed in the hydraulic circuit.

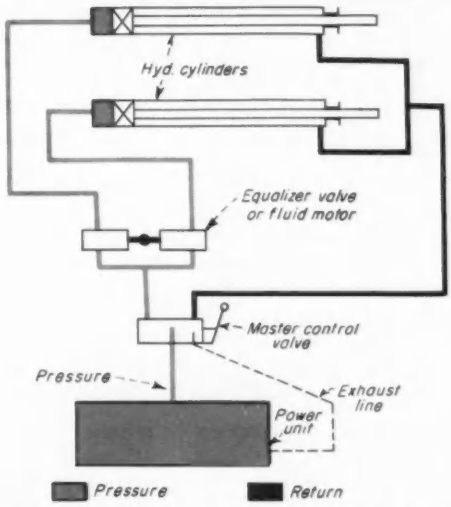
The problem is simplified also by keeping the magnitudes of the loads acting against each piston of the same order of magnitude. Conditions on the supply end of the cylinders are important, too. In many of the circuits, synchronization is achieved by equalizing the hydraulic flow to the cylinders. For simplicity, all cylinders in the accompanying sketches are assumed to be identical in size.



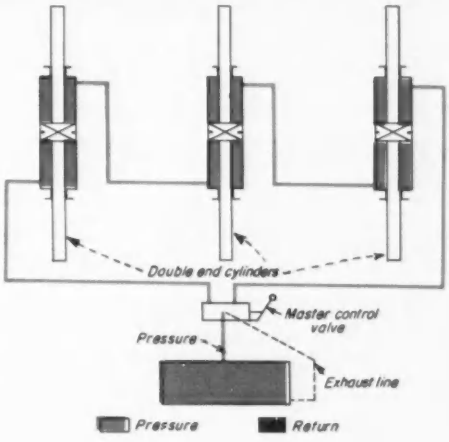
1. FLOW CONTROL VALVES can be adjusted independently until pistons operate in unison. Although used in many applications, this method is one of the least accurate. All variables, such as loads, friction and leakage, should be as nearly the same as possible for both cylinders. The manifold line entering the cylinders should be of sufficient size to offer the least resistance to fluid flow.



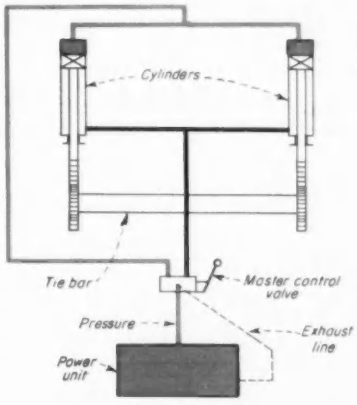
4. DUAL AIR-HYDRAULIC CYLINDERS. This method is extremely satisfactory where high pressures are not involved. Air is the power medium and hydraulic fluid is the control medium. The hydraulic cylinders are in a closed, series hook-up. The hydraulic cylinder is of the double end type with piston rod on both sides of the piston. The piston rod on one side forms the rod for the air cylinder. The hydraulic piston is packed with an "O" ring while the air piston is packed with cup type packing. A circuit of this setup is ideal for fine feeds. In effect, the hydraulic cylinders act as dampers or dash pots for the air-driven pistons.



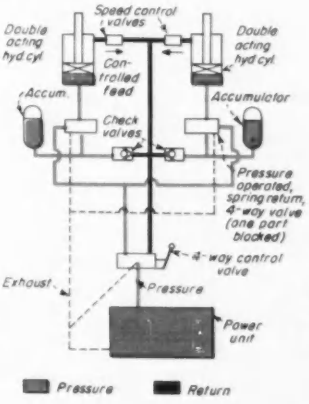
2. EQUALIZER valves prove a satisfactory method for synchronizing movement of hydraulic pistons. The equalizer valve is primarily a measuring means for dividing the fluid flow and supplying half of the flow to each piston. Or, two fluid motors, mechanically coupled, can be inserted in place of the equalizer valve. Variations in loads or friction drag have little effect on movements.



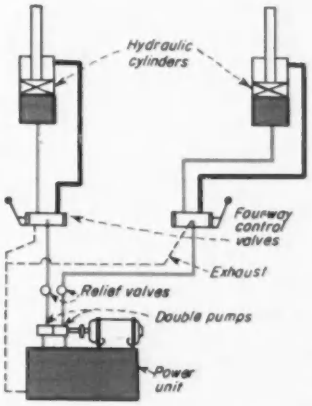
3. SERIES CIRCUIT. This method is often put into practice where several cylinders are involved. Although this method works to a high degree of satisfaction, precaution must be taken that there is no internal or external leakage in the cylinder. The lines between the cylinders must be full of oil. Air cannot be tolerated in the system. An objection to this method is the use of double end cylinders which may not fit into the design of a machine due to the space required for rod extensions.



5. MECHANICAL COUPLING. Piston movement is regulated by the use of gear and rack design. This method is often used where a pair or group of cylinder pistons are moving in the same direction. It is an accurate means of synchronizing piston cylinder movement, especially on very heavy equipment. The design is simple and the results, satisfactory. Another type of mechanical coupling employs a cable-and-pulley hookup between pistons.



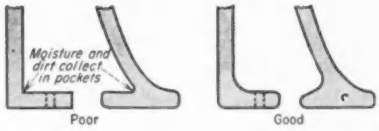
6. ACCUMULATORS AND FLOW CONTROL VALVES. This method has proven satisfactory on short stroke cylinders. The accumulators fill at the end of each instroke and are ready to discharge into the head end of the cylinders when the four-way master control valve is shifted. Purpose of the accumulators is to supply a uniform, shockless flow to each cylinder on the out or extend stroke. Minimum leakage in valves and cylinders is required.



7. DOUBLE PUMPS. Synchronizing piston movement by the use of double pumps of same capacity on power unit. This method is sometimes used to synchronize cylinder movement but all conditions must be favorable. Leakage must be at a minimum at all times for proper functioning. In addition, the loads on both pistons should be of the same magnitude. Here again, synchronization was effected by assuring equal oil supply to both cylinders.

Recommended Design Details

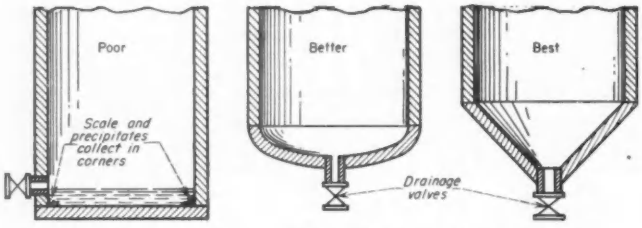
ATMOSPHERIC CORROSION

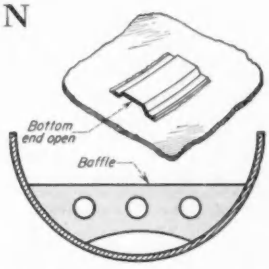


STRUCTURAL MEMBERS should be arranged so that moisture or liquids will not collect. Inverting angles and channels prevents this condition. Drilling holes is another method to insure proper drainage.

ROUNDED CORNERS and smooth contours should be used whenever possible to prevent the accumulation of moisture, liquids and solid matter. Using corrosion resistant materials is often found to be more economical due to greater service life.

CONCENTRATION CELL CORROSION

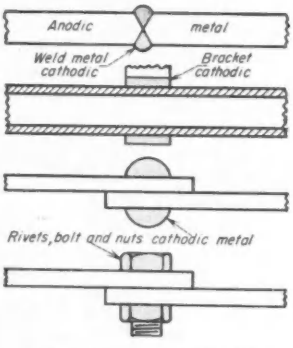




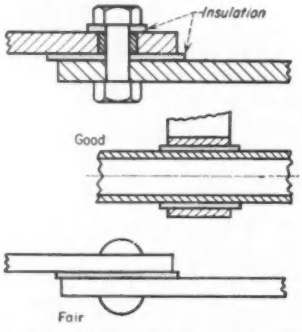
ALL LIQUID CONTAINERS should be designed with smooth and rounded corners. Sharp corners, stagnant areas and other such conditions are favorable to the accumulation of precipitates, solids and scale which promote concentration-cell attack. Sloping bottoms should be used with valves arranged for complete drainage.

ALL BAFFLES and internal stiffeners in tanks should have openings and arranged to avoid liquid pockets and permit the free drainage of fluids.

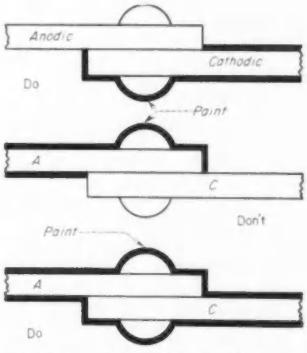
GALVANIC CORROSION



IN JOINTS and connections, the proportions of dissimilar metals should be chosen so the anodic or less noble metal has the greater exposed area (see Table I p 104). All fastenings such as bolts and rivets should be made of the more noble or cathodic material.

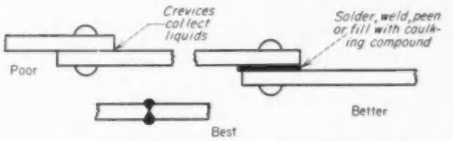


WHEN POSSIBLE the connection of dissimilar metals should be separated by an insulating material to reduce or prevent the current flow in the galvanic circuit. Paint or plastic coatings serve to reduce the galvanic current by increasing the circuit resistance.

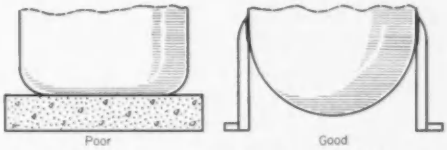


PAINTED COATINGS should be applied with caution. Do not paint the less noble material, otherwise greatly accelerated corrosion will occur at imperfections in the coating. When possible all exposed surfaces should be painted.

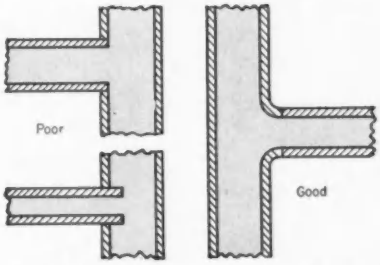
to Reduce Corrosion



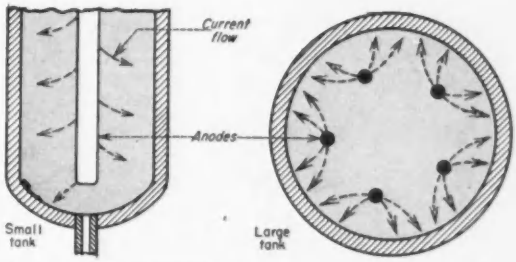
BUTT WELDED JOINTS are less likely to corrode and should be used. If lap joints are required, all exposed edges should be filled with a non-absorbing caulking compound or welded to prevent retention of liquids in crevices.



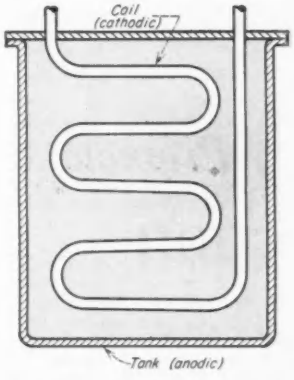
STORAGE TANKS and other containers should be supported on legs to allow a free circulation of air underneath. This prevents the possibility of any condensation and collection of moisture under the tank.



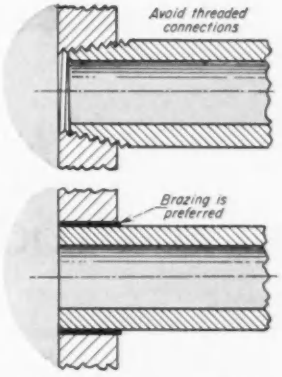
IN THE DESIGN of liquid passages, all pipes and connections should be constructed to insure uniform flow, with a minimum turbulence and air entrainment. This also reduces settling of solids.



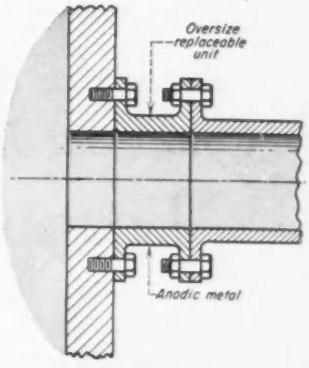
CATHODIC PROTECTION of containers with corrosive liquids can be done by immersing a rod of a more anodic material inside. This reverses the galvanic current and the container becomes cathodic and is less likely to corrode. Magnesium and zinc rods are often used.



IN DESIGNING EQUIPMENT, keep different metals far apart in the solution; this increases the resistance of the electrolytic path. Chemical inhibitors are often added to corrosive solutions. Bare zinc, magnesium or steel in the liquid counteracts corrosion.



IN JOINING DISSIMILAR MATERIALS, well apart in the galvanic series, avoid threaded connections since the threads deteriorate rapidly. Brazed joints are preferred using a brazing alloy more noble than at least one of the metals being joined.



AT CONNECTIONS of dissimilar materials, consider using small replaceable sections made of the less noble metal. These expendable parts should be easy to replace and made oversize to increase their corrosive life. Non-metallic gaskets increases the circuit resistance.

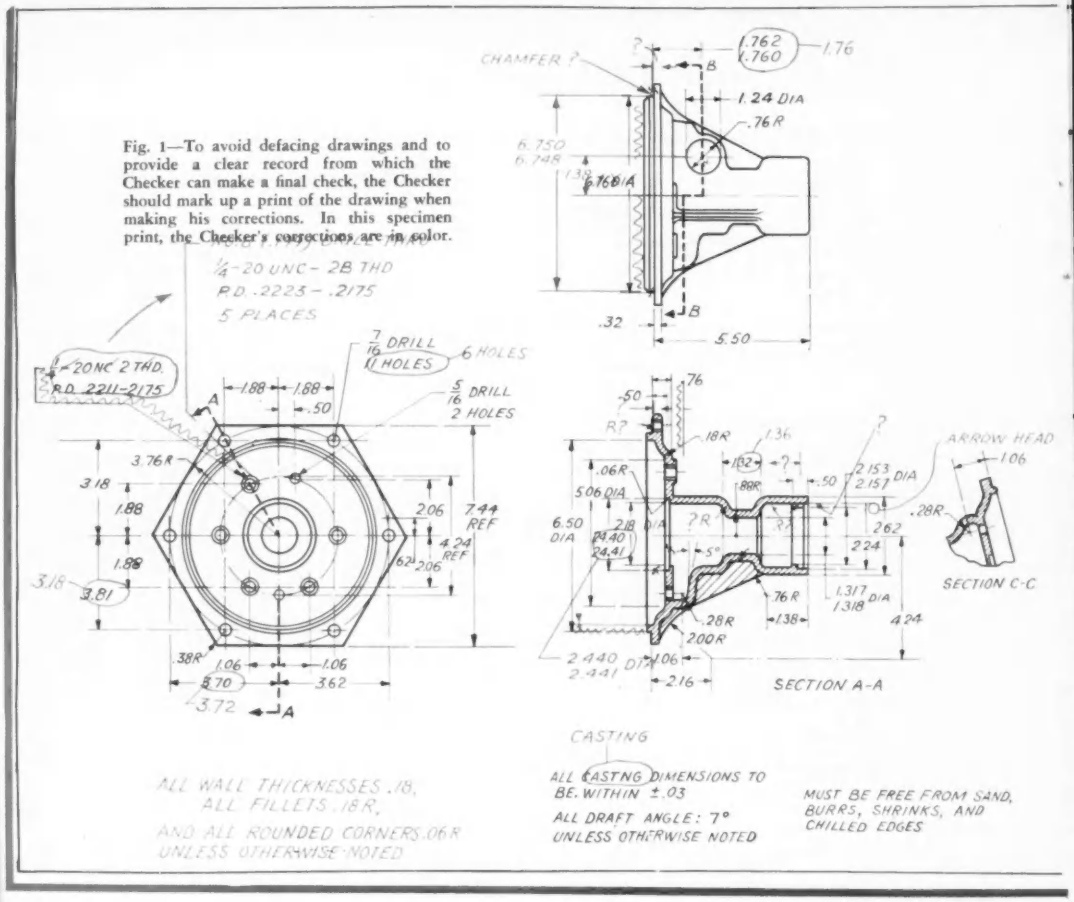


Fig. 1—To avoid defacing drawings and to provide a clear record from which the Checker can make a final check, the Checker should mark up a print of the drawing when making his corrections. In this specimen print, the Checker's corrections are in color.

Competent Engineering Checkers Promote Economical Production

GEORGE E. ROWBOTHAM
Standards Engineer Consultant

IN ANY ENGINEERING DEPARTMENT, the main functions of a Checker are to see that costly errors are not made, to insure uniformly correct interpretation of drawings, and to avoid confusion in engineering instructions, specifications and requisitions issued to the purchasing and manufacturing divisions of his company or organization.

The competent Checker has a sound engineering background and a thorough knowledge of manufacturing. His experience usually consists of a minimum of ten years in drafting and shop work. He probably started as a tracer, became a detailer, then a layout draftsman, and so on up the rungs of the ladder.

Not every ambitious draftsman, unfortunately, has the proper adaptiveness to be a Checker. The outstanding characteristic needed is a facility and feeling for detail and precision. Because of this trait draftsmen like to refer to Checkers as "cranks" and "old fuss-pots". The nature of the Checker's work makes him a critic. Since it is his job to catch the draftsman's errors, he is often an unpopular man around a drafting room. The draftsman's

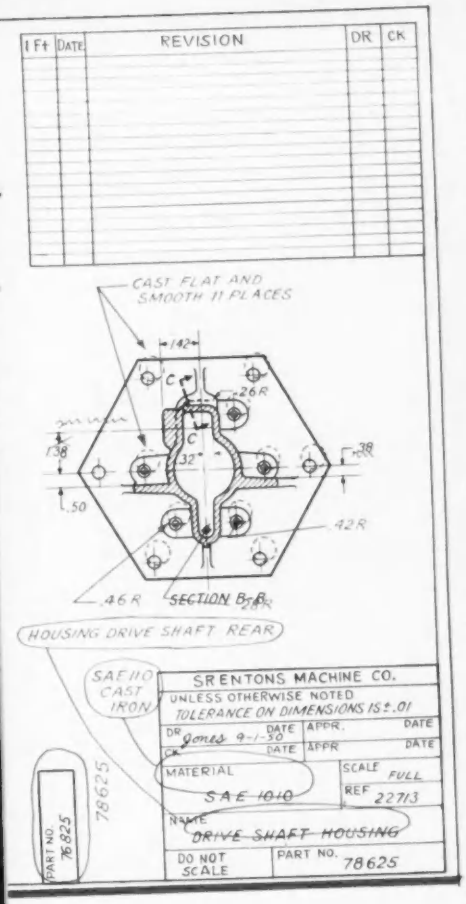


Table 1—Drawing Details and Notations That Must Be Checked

1. Is general appearance of the drawing satisfactory?
2. Is tracing free from dirt and tears? Is back of tracing clean?
3. Are figures, letters and lines correctly formed, clean and dense enough to assure good reproduction and legibility?
4. Does the drawing conform with Company Engineering Drafting Standards?
5. Are necessary views and sections shown, and are they in proper relation to each other?
6. Is drawing to scale?
7. Are all necessary dimensions shown?
8. Do witness lines extend to the correct surface?
9. Do arrowheads extend to the correct witness lines?
10. Do the dimensions agree with the layout and related parts?
11. Has consideration been given to dimensioning to avoid unnecessary calculations in the shop?
12. Are necessary notes, data and charts provided?
13. Does any duplication of information exist? For instance, are dimensions duplicated or does the same information exist on both the detail and assembly drawings?
14. Is there a duplication of parts?
15. Are all necessary symbols for finishing, grinding, welding, and other operations shown?
16. Are sufficient notes, including concentricity, parallelism, squareness, and flatness shown?
17. Has the title block been filled in completely, and is information correct? Is the title correct?
18. Are all required approval signatures recorded? For instance, has the drawing been signed by authorized laboratory personnel for material, heat-treatment and finished specifications given?
19. Are material and heat-treatment specifications given?
20. Are plating and painting specifications, either for protection or decorative purposes, given?
21. Are the correct drawing, die, casting, pattern and forging numbers given?
22. Is the stock size specified?
23. Is the hand of left and right-hand parts correctly designated, and is the part drawn in its correct position?
24. Are Standard Parts used wherever possible, and are they properly specified?
25. Are proper finish allowances provided?
26. Will the part interfere with other parts in assembly and operation?
27. Are proper limits or tolerances for desired fits given?
28. Are undesirable limit accumulations present?
29. Are stationary and moveable clearances sufficient?
30. Are proper draft angles, fillets and corner radii given?
31. Is the approximate developed length of finished part shown?
32. Are required trade mark, and manufacturer's identification instructions given?
33. Is the part designed to facilitate production?
34. Is the part sufficiently strong and suitable for the work it has to do?
35. Is there proper alignment of oil holes, drilled holes, and studs with mating parts?
36. Has accessibility been provided for welding and riveting tools?
37. Can the part or parts be assembled and disassembled with the necessary tools? For instance, is there provision for adequate wrench clearance for all nuts and bolt heads?
38. How does the drawing compare with previously released drawings of similar parts?
39. Has the assembly drawing been changed to agree with the revised detail drawing?
40. Have installation drawings been revised to agree with latest production drawings?
41. Has the original drawing, when redrawn, been properly marked?
42. If consideration should be given to the prevention of dirt, grit accumulation and other foreign matter on oiled or greased working parts have provisions been made so they can be easily cleaned and inspected?

feelings are easily understood—most of us, being human like him, dislike being shown our errors.

Checkers are often accused of everything from changing drawings because of a personal grudge to the desire to impress the Chief Draftsman. Nothing could be further from the truth. Contrary to such false accusations, many draftsmen owe their continued employment to the skill and ability of a Checker.

In any disagreement between a Checker and draftsman, the Checker should take the initiative to bring out a workable understanding. He should understand and appreciate the draftsman's feeling and work attitude based upon his own experience as a draftsman. He should exercise extreme patience with the draftsman and be willing to explain the reason for each

change. The Checker's experience, if properly applied, will become part of the draftsman's "know-how" through constant association and application.

The success of drafting standards depends largely upon the Checker. These important critics of drawings can do much toward directing the draftsman in the application of standards until familiarity has been thoroughly established. Checkers are definite safeguards against laxity in the application of standards.

When questions arise concerning practices not covered by accepted standard practice, the Checker is often confronted with the fact that the draftsman has employed practices contrary to the Checker's personal preference. In all such events, if it is apparent that the drawing in question will be clear to the user the Checker disregards personal preference and approves the drawing. If any shade of doubt exists regarding the intent of the drawing, however, or if it is definitely incorrect, the Checker recommends that the draftsman change the drawing.

If a general inspection of the drawing reveals that it contains errors as a result of outright negligence on the part of the draftsman, the Checker returns the drawing for a complete review by the draftsman without further check.

In performing the duties called for in Table I, it is within the Checker's province to suggest design changes when he sees fit to do so. When his suggestion would make a change in design necessary, the change may be made only upon the approval of the engineer responsible for the design.

In addition to checking the dimensions and views shown on a drawing, the Checker constantly checks for information that is lacking because either of carelessness or lack of knowledge on the part of the detailer.

The checker uses a print, Fig. 1, for the corrections to avoid defacing the drawing and to provide a clear record from which he can make the final check.

The Checker's signature on a drawing carries definite responsibility. The accuracy and legibilty of the information on the drawing, conformance with accepted standard practices, the application of the part, both in relation to itself and to associated parts, as well as the completeness of the drawing, are all the responsibility of the Checker.

After a draftsman has "gone through the mill" and has proven to be good material and is at last ready to be elevated to the post of Checker, he is frequently extremely reluctant to accept the job. This reluctance is not surprising because, unfortunately, the Checker does not enjoy the high rank in the engineering department to which his services should entitle him. However, there is one definite advantage to a Checker's job. It is a stepping stone to the positions of Assistant Chief Draftsman, Chief Draftsman, Project Engineer, Standard Engineer, and other positions on a staff level. There are many Chief Engineers who were once Checkers. The wise draftsman will accept a Checker's job any time the opportunity is offered.

Bonding Titanium Carbide With Various Elements

EFFORTS TO INCREASE the power of aircraft turbines have raised a number of power plant problems. One of which is the need for materials suitable for use at temperatures higher than those currently prevalent. The National Advisory Committee for Aeronautics, in Technical Note 2187, reports that some materials that show considerable promise for high temperature application in jet engines have been fabricated from combinations of ceramics and metals by the sintering process.

This process affords a means of producing compositions at temperatures below the melting point of the ceramic constituent. Controlled sintering of a powdered ceramal compact is generally recognized as a method capable of producing satisfactory homogeneity and grain size. Investigation of high temperature properties and of mechanisms for alloying and for bonding of metallic and ceramic materials is necessary for the maximum utilization of ceramals in aircraft power plants.

An investigation was made at the NACA Lewis laboratory to study the bonding of titanium carbide with various elements. A secondary purpose was to accumulate information regarding the mechanism of bonding.

Although the conditions of this investigation were not directly analogous to those prevalent in the sintering of a body of intimately mixed powdered constituents, the reactions between the powdered elements and the solid titanium carbide in this bonding investigation appeared indicative of those between intimately mixed discrete particles as in a sintered powder body.

Titanium carbide was selected as the base material for bonding studies and theoretical evaluations because of its relatively high thermal shock resistance.

Cupped hot pressed bodies of titanium carbide were obtained, and metallographic examinations of sectioned specimens were made in order to determine the type of bond between the titanium carbide and the elements. In those instances where the metal pellet separated from the titanium cupped surface during a careful microspecimen preparation, evaluation of the bonding characteristics was impossible. In each instance that the interface failed in the preparation of the microspecimen, additional specimens were made and observed for confirmation.

Of fifteen elements individually fused on solid high density titanium carbide at minimum fusion temperatures in a helium atmosphere and at atmospheric pressure, only nickel, cobalt, chromium, and silicon produced bonds with titanium carbide.

Metallographic studies of the interface between the element and the titanium carbide in the four bonds indicated that nickel and cobalt appeared to produce extensive interlocking bonds, with nickel showing the greater penetration.

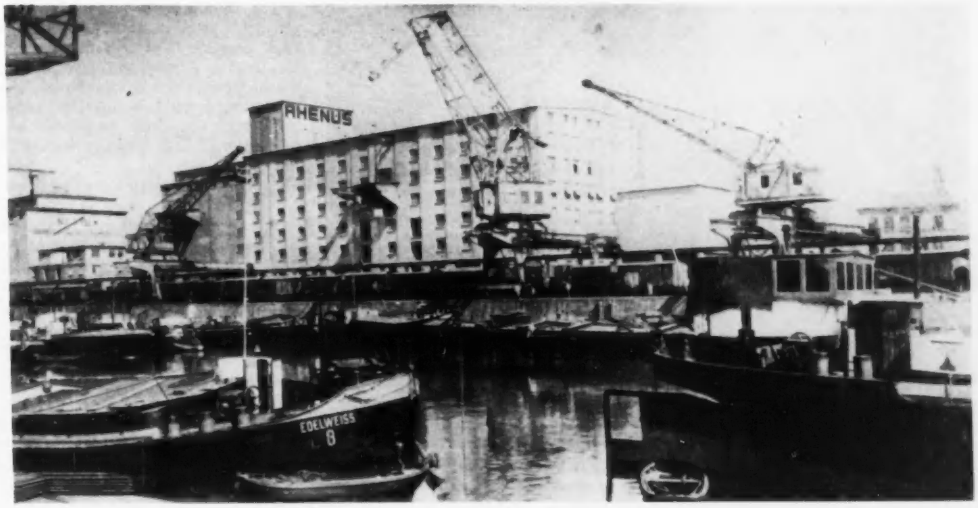
The observed interfaces provided information concerning some of the reactions involved in bonding of elements to solid titanium carbide.

The eleven elements that did not bond with titanium carbide under the conditions in this experiment were: aluminum, beryllium, columbium, gold, iron, lead, magnesium, manganese, platinum, titanium, and vanadium.

Solid titanium carbide was used as the base material in bonding investigation with the fifteen elements. The appearance of small angular shaped precipitates in the nickel rich and cobalt rich zones somewhat substantiated the solubility of titanium carbide in nickel and cobalt. Employment of nickel, cobalt, and possibly chromium as binder materials for sintered titanium carbide bodies appeared promising.

The criterion of metallographic evaluation of the element-titanium carbide bond in this investigation was taken as the presence of a mechanical interlocking structure or the formation of a new phase, with no consideration given to the strength of the element. The value of an element as a binder was assumed proportional to the extent of penetration of the matrix by an interconnected phase.

TECHNICAL NEWS



A PHOTOGRAPHIC REPRODUCTION on aluminum. Features of the Aluphoto process include a high degree of resolution, permanence and durability. Plates are processed under normal darkroom procedures and use standard photographic equipment.

Photographic Reproductions on Aluminum

THE PROCESS OF MAKING PHOTOGRAPHIC REPRODUCTIONS on aluminum is a recently developed Swiss invention now being introduced into the U. S. by Horizons, Inc. of Princeton, N. J. and Cleveland, Ohio.

The properties of the Aluphoto plate which reflect its usefulness are: 1. Simplicity of handling and processing. 2. Resistance to destruction and deterioration under a variety of conditions including immersion in boiling water, salt spray and salt water, light, weathering, temperatures up to 600 C. The material is scratch resistant and unaffected by oils, fats, organic solvents, food stuffs and food acids. 3. Ease of cleaning due to smoothness of surface. 4. High degree of resolution. The image is substantially grainless, permitting reproduction to a degree of detail equivalent to 40 micro-inches. 5. Adaptability to cutting and trimming to size.

Aluphoto plates are now being used in European industries. Typical applications include name photos, sign plates, instrument scales and dials, switchboards, slide rules, graphic descriptions of designs, watch faces, rules, and protractors. Some military applications are field and sea maps, document duplications for permanence, identity cards and aircraft and shipboard instruments and panels. Artistic and ornamental uses are obvious and numerous.

In general the permanence and durability of the image formed on an Aluphoto plate have provided the possibility of advantageous substitution for materials normally used in industry. These include chromatized gelatine on metal, vitreous enameled metal, photographic film on glass, wood or metal, decals, etched metal and similar devices.

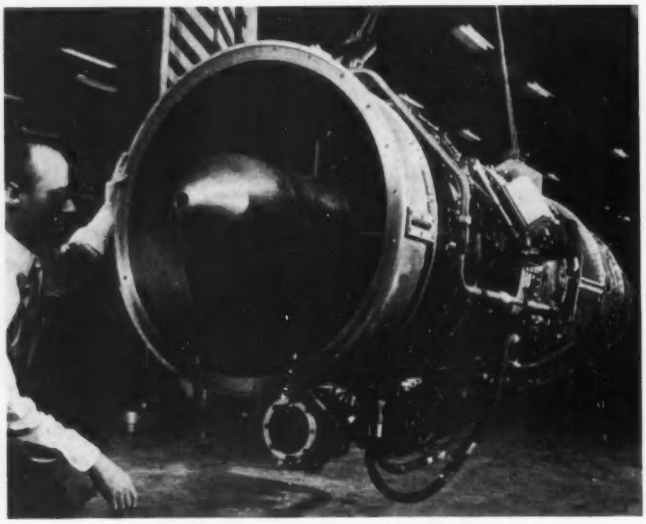
The Aluphoto plate is a photosensitive anodized aluminum plate. The photographic image is developed in the anodized layer. Plates are supplied to the customer in a non-sensitized condition and may be handled without special precaution. After sensitization and developing the surface may be heat sealed by boiling in water for 20 min to obtain a glass-like hardness.

The Aluphoto plates are supplied in two main types: Type A, which is transparent and colorless and Type B which is opaque and pearl grey colored. Black on white or white on black finishes are obtainable. Bright, half dull and dull finishes can also be supplied.

The non-sensitized plate is processed in two simple steps, sensitization and photographic processing. Both steps are carried out under normal darkroom procedures.

The sensitization procedure consists of dipping the plate alternately for 2 min. in Aluphoto baths, A, B, C and again in A, rinsing in water after each dip. The plates are dried in a light-tight box at 40 to 50 C for 10 to 15 minutes and are then ready for photocopying. The process is very similar to that used with paper.

THIS CIRCULAR SCALE presents a typical industrial application of the Aluphoto process. The minute detail obtainable and the dimensional stability of the aluminum offer advantages over other types of processes and materials.



ADVANCED J-47 TURBOJET is the same size as the current J-47 but is more powerful. Accessories have been placed underneath to provide a greater air inlet area.

Advanced J-47 Turbojet Has Higher Power Output

NEW YORK—A new turbojet engine, the same size as the J-47 battle-tested jets but far more powerful, has been developed by the General Electric Company. Described as an important step in the world race for jet supremacy, the new engine incorporates all the best features of the current J-47 as proved in thousands of hours of service, plus the results of advanced research and testing. The current J-47 is the powerplant for such top Air Force planes as the North American F-86 "Sabre" fighter and the six-jet Boeing B-47 "Stratojet" bomber.

Although its power output cannot be revealed, the advanced tourbojet puts out far more thrust than the present engine which is rated in excess of 5,200 pounds. (Turbojet power is rated in pounds of thrust, or driving force, exerted.)

Designated the J-47-GE-21, the turbojet is the first of a new series to be announced. It is an all weather engine with anti-icing features and high altitude starting characteristics and may be equipped for either water/alcohol injection or afterburning for greatly added thrust power for short periods. A tailpipe variable jet nozzle may be added to obtain maximum efficiency.

The new engine was developed in record time, 18 months from the time drawings were under way until 50-hour tests were completed, and was designed for best performance compatible with simplicity and reliability as well as producibility.

Defense Status of Engineering Graduates Of 1951

AS ONE PHASE IN ITS STUDY of the already critical and increasing shortage of engineers, the Engineering Manpower Commission of Engineers Joint Council is concerned with the class of engineering students who were graduated this June. Previous studies by the Manpower Committee of the American Society of Engineering Education and the U. S. Office of Education indicate that this year's class numbered about 38,000.

The demands for engineering graduates by the military and industry for defense purposes have been stepped up. Public statements of Major General Lewis B. Hershey, Director of the Selective Service System indicate that the brunt of the draft calls will be borne by the students who were deferred to complete their education. A 30-day postponement of induction is being granted to enable a graduate to enlist in the branch of service of his choice or to find employment in a critical occupation in essential industry, which the employer has not otherwise been able to fill.

The Engineering Manpower Commission was desirous of determining what proportion of the current graduating class would be taken by the armed services through the R. O. T. C. programs, through the reserve forces or through the draft, and what proportion would be available for industry.

A letter was mailed to the Deans of the 135 engineering colleges accredited by the Engineers Council for Professional Development to learn the status of this year's graduates. The 86 colleges answering the questions expected to graduate 18,630 engineers. This represents about one-half of the expected graduates. The following proportions are based upon the answers received.

(A) Eleven percent are to be commissioned in Armed Services or Reserves thru R. O. T. C. training.

(B) Sixteen percent are enlisted members of Reserves or National Guard.

(C) Thirty-six percent will be draft eligible after graduation.

Thus 63 percent of the current graduating class are available to the Armed Services.

It is reasonable to expect that all of the 11 percent to be commissioned as a result of R. O. T. C. training and possibly half of the 16 percent who are enlisted members of the reserves or National Guard will be called to active duty promptly.

Even after adjusting the estimate of 36 percent draft elegibles to reflect the percentage of 4F's determined in studies by the U. S. Office of Education, those who will become draft elegible will still be about 31 percent of this year's class.

Should the Selective Service System induct the draft elegibles, and there are indications that they will make every effort to do so, there will be only about half of the 38,000 engineering graduates left to fill industrial needs.

Industry can thus count on only about 19,000 engineering graduates this year. The shortage of engineers will be made even more acute by losses of existing engineers to the Armed Services. A previous survey this year showed that 25 percent of the engineers employed in industry were enrolled in the reserves.

The Armed Services need ships, planes, tanks, guns, trucks, radar, radio, sonar and other modern devices of war. To be able to supply them, industry needs its engineers!

Starting Jet Engines By Artificial Respiration

AT ADVANCED BASES where external power units are unavailable or in extremely cold weather when the effectiveness of such starting sources is reduced, the exhaust blast from one jet fighter can be used to start the engine of another directly behind it.

This unique starting method is the result of tests that were made in Korea because a number of F-86 aircraft were operating from advanced bases subject to rapid alerting conditions. In such situations, aircraft in which the battery system was inoperative or which had landed at an emergency field where no external power units were available, might have to be abandoned unless some other means could be employed to provide the initial starting rotation.

Pennsalt Announces New Chemical Bath to Remove Scale From Forgings

PHILADELPHIA—A pre-heat chemical bath that completely removes furnace scale from steel forgings during quenching has accounted for cost savings of 90 percent over previous methods used in industrial production.

The bath is made up of a new product, Pennsalt SR-4, dissolved in weak muriatic acid and water developed by the Pennsylvania Salt Mfg. Company.

Furnace or forging scale must be removed from all forgings before machining. These forgings, which are widely used in automobiles, trucks, tractors, railroad equipment, armaments and other types of machinery, must be machined to close tolerances. Forging scale is an iron oxide which is harder than steel, is very abrasive, and clings tenaciously to the forgings.

If it is not removed completely, it interferes with machine tool setting and quickly wears down cutting tools. If left on finished parts, pieces of the scale will eventually drop into mechanisms, such as transmissions, and wear other working parts rapidly.

The Pennsalt SR-4 bath requires no heating and is made up in ordinary rubber lined tanks. Dipping baskets can be made of simple sheet iron. Parts covered with forging scale are immersed in the bath for five minutes and then may be placed directly into heat treating furnaces or can be stored for later heat treating.

The forgings are heat treated at a temperature range from 1,500 to 1,600 F and soaked at temperature for the minimum time consistent with good metallurgical practice. An additional saving results from the fact that the forgings can be heat treated in a non-reducing atmosphere or without a prepared atmosphere.

Following the heating the forgings are water quenched and tempered. In conventional operations, the tenacious furnace scale is then removed by expensive sand- or shot-blasting, but with the use of the SR-4 bath, this process is completely eliminated in most operations. When the forgings treated with SR-4 are water quenched, the scale actually blasts off from all surfaces, leaving them perfectly clean for subsequent machining.

Both laboratory tests and plant operations have shown that the SR-4 bath provides for complete removal of scale from carbon steel forgings, even from deep indentations and blind holes difficult to reach in sand- or shot-blasting. The bath provides for efficient scale removal after heat treatment in most cases where oil quenches are used, and in such cases where scale removal is not complete, sand- or shot-blasting operations can be reduced considerably.

Satisfactory results have been obtained in SR-4 descaling of plain carbon steels and several different types of SAE alloy steels.

UNTREATED FORGING (left) is shown after conventional heat treating and water quenching (center). Piece on right, free from forging scale, had only SR-4 bath.

Ceramic Coatings Prevent Exhaust-Gas Corrosion

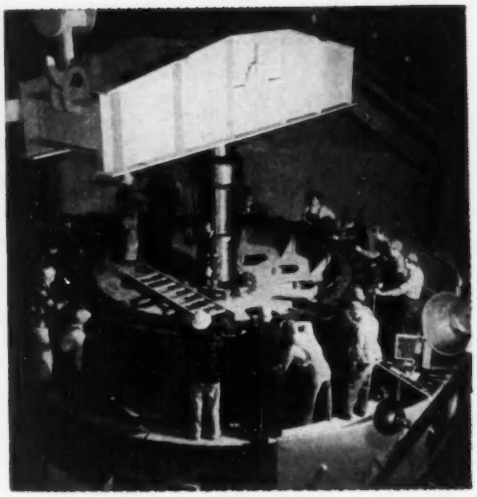
AN INVESTIGATION OF the corrosive effects of lead bromide vapors on various heat-resistant alloys, both with and without protective ceramic coatings, has recently been completed at the National Bureau of Standards. Lead bromide, which is the principal lead compound present in aircraft exhaust gases, has been suspected of contributing significantly to exhaust-system corrosion but until now available data have been few and inconclusive. The NBS investigation demonstrates that the uncoated alloys corrode fairly rapidly when exposed to lead bromide vapors at high temperatures, but that certain ceramic coatings effectively prevent corrosion under the same conditions.

Lead bromide is present in the exhaust gases of all engines that use leaded gasoline as a fuel. Aviation gasoline is more heavily leaded than automobile fuel, however, and aircraft exhaust temperatures are higher. For these reasons, corrosion from lead bromide is a greater possibility in aircraft than in automobiles.

The lead bromide found in exhaust gases results from the interaction of tetraethyl lead and ethylene dibromide, the active additives of leaded gasoline. The tetraethyl lead is added to improve combustion characteristics, while the ethylene dibromide acts as a scavenging agent. In this capacity the ethylene dibromide converts the lead oxide, which would otherwise be formed during combustion, into lead bromide. Lead bromide has a considerably higher vapor pressure than lead oxide and is therefore more readily passed through the exhaust system as a vapor.

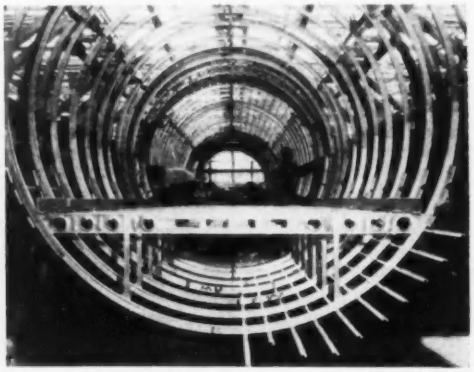
Five heat-resisting alloys were investigated: Inconel (a high nickel alloy), types 347 and 19-9DL stainless steels, Vitallium, and S-816. The first three alloys are in regular use in exhaust systems. Vitallium and S-816 are turbine blade alloys and, although too expensive for general exhaust sys-

LATEST ANTI-AIRCRAFT GUIDED MISSILES are fired and steered by complex electronic control systems. The heart of each control system consists of computing devices developed by Bell Laboratories that receive target altitude, course and speed data from electronic radar tracking units.



LARGEST MOTOR EVER INSTALLED, a 330-ton, 65,000 hp giant, is assembled in the new pumping plant at Grand Coulee Dam on the Columbia River. With all other parts in place, the rotor is being set in position by two overhead cranes, using an equalizer. Motor is 25 ft high, 100 ft in dia.

THE RAMBLER COUNTRY CLUB, built by Nash Motors, is a new, fully equipped hard-top convertible with large full-vision windows. Like other Rambler models, it has an advanced type of steering and front end suspension for ease of control, driving comfort and outstanding maneuverability.



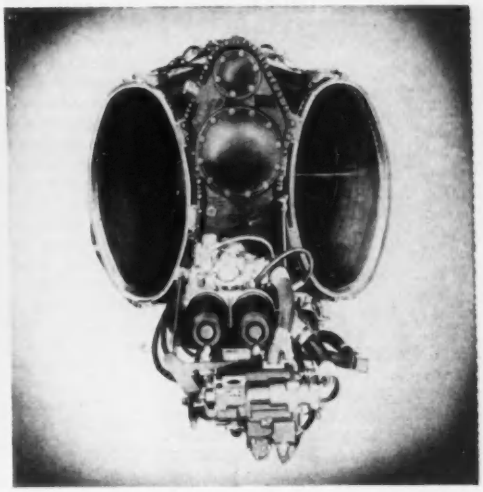
PRODUCTION-TYPE FIXTURES insure dimensional accuracy to the first metal mock-up of a Convair-Liner 340. Almost an exact replica of a production model transport, the mock-up serves as a three-dimensional layout for all design stages including the planning of all electrical wiring and tubing.

tem use, could be used for small critical parts. Specimens of each alloy with five different coating conditions were studied: an uncoated specimen, a preoxidized specimen, and three ceramic-coated specimens. The ceramic coatings, all commercially available, were NBS types A-417, A-19, and A-520. Specimens were exposed to lead bromide vapor for six hours in an air atmosphere at temperatures of 1,350, 1,500, and 1,650 F. Determination of the effectiveness of the ceramic coatings did not require that the lead bromide vapor concentration be kept constant.

At one-hour intervals, the specimens were removed, examined, and then replaced together with a new charge of lead bromide. This hourly examination included cleaning of a limited area of the specimens—which were in the form of flat strips—and measuring the loss in metal thickness from corrosion. Loss in weight was also measured in some instances. At the end of the tests, cross-sections of the specimens were studied microscopically, and both the scale layer and the cleaned alloy surfaces were examined spectrochemically for lead content.

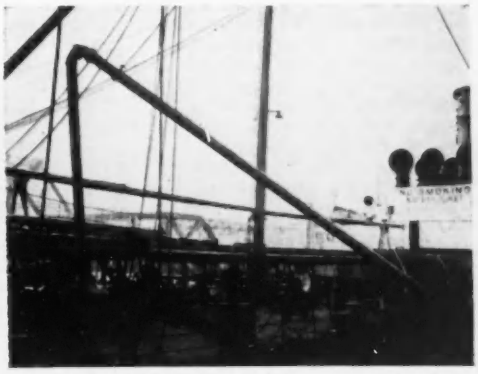
Large differences in the resistance

HUGE FUEL CELL for B-47 Stratojet bomber is placed in 15 x 48 ft vulcanizer, one of the largest in the industry. The vulcanizer was recently installed in the Fort Wayne plant of U. S. Rubber Co. to handle fuel cell production for the B-47 bomber. Door is 34 feet high, vulcanizer weighs 78 tons.



A HEAD-ON VIEW OF the Westinghouse J40-WE-6 turbojet engine, which delivers more thrust than any other jet engine known to be in production today. In this picture can be seen the split air intake with the gearbox to drive accessories mounted snugly between the Y-shaped arms of the intake.

FIRST MOTORIZED EQUIPMENT engineered specifically for fighting oil and gasoline fires has been developed by the Naval Research Laboratory. Believed to be the most efficient of its kind in the world, the new system uses mechanically-produced foams of air, water and protein solutions.



ALUMINUM HOSES and swivel joints save weight and will handle many types of products injurious to rubber or rubber-base compounds. Dock installation shown above is engineered for easy handling and quick connections. Loading time is considerably less than with rubber hoses.

of the several alloys to attack by lead bromide were found: although all five uncoated alloys suffered corrosion at all test temperatures, the loss of thickness in the full 6-hour period ranged from 1.2 to 10.1 mils. Alloys S-816, Vitallium, and Inconel were notably more resistant than the 19-9DL and type 347 stainless steels, both of which are high-iron, austenitic-type alloys. Microscopic examination indicated that a selective attack took place with the 19-9DL and 347 steels, leaving a spongy layer near the surface. With the other alloys, however, very little selective penetration was found.

Preoxidation of the surfaces of the alloys tended to retard corrosion for the first hour or two only, after which corrosion proceeded at an undiminished rate. Preoxidation was accomplished by heating specimens in air for 4 hours at the test temperature.

No consistent relation was found between temperature and rate of corrosion; some but not all of the alloys showed less corrosion at the higher temperatures. Similar results have been reported by other investigators of alloy corrosion and are apparently not unusual. However, it must be remembered that in this test the lead bromide concentration was not constant.

Supersonic Wind Tunnel Uses 180,000 Hp Drive

A 180,000 HP WIND TUNNEL DRIVE, the greatest power output ever to be concentrated on a single shaft, is included in General Electric equipment ordered recently by the National Advisory Committee of Aeronautics. The giant electric motor unit and a companion 110,000 hp drive will be installed in two supersonic wind tunnels at Ames Aeronautical Laboratory, Moffett Field, California.

The 180,000 hp installation will be used to power a new, record-breaking eight-foot tunnel which will create wind velocities several times the speed of sound. The drive will consist of four, 45,000 hp, 720 rpm variable speed a-c induction motors mounted in tandem on a single shaft to drive either of two axial-flow compressors.

Largest of their kind ever built, the motors will weigh more than 145 tons apiece and each will be the size of a small room. Rated at 180,000 hp, the four-motor drive will have a peak one-hour output of 216,000 horsepower. The system will use slip-regulator control.

The second unit, rated at 110,000 hp, will be used at the Ames Laboratory's present 16 foot tunnel, replacing the 27,000 hp drive installed there a few years ago. Using three propellers operating on a single shaft, this tunnel will create wind velocities ranging from 350 to 920 mph.

This drive will be comprised of two 41,500 hp and one 27,000 hp variable speed a-c induction motors. Combination slip-regulator and Clymer System speed control will be used. The Clymer set-up will consist of two motor-generator sets linked in for greater speed control and to provide easier starting without excessive drain on the power supply.

World's First Gas Turbine Helicopter

LONDON—The world's first helicopter powered by a gas turbine is to go into production. It is the SO 1120 Ariel III, which made its first flight on April 19 at Villacoublay. Designers and makers are the Societe Nationale des Constructions Aeronautiques du Sud-Ouest (SNASO).

The Ariel III is a 3-seater general purpose helicopter, ordered only about a year ago. It has a turbomeca Artouste gas turbine of 220 hp which is used to drive a compressor. Air enters through the hub of the lifting rotor and along the hollow blades to the combustion chambers at the rotor tips where fuel is injected.

Residual thrust from the turbine is used for directional control in place of an ordinary rudder. This idea was first exploited in a British machine made by the Cierva Company and demonstrated at Radlett four years ago.

The advantage of driving the rotor by means of jet units at the blade tips is that there is no need to counterbalance torque as there is in the conventional helicopter. A tail rotor, is superfluous. Greater stability is claimed, and there is a reduction in the gross weight and in mechanical complication.

Top speed of the Ariel III is 135 kilometers an hour (84 mph), and its range with a load of 450 kilograms (992 lb) is 100 kilometers. Service ceiling is 4,400 meters (14,400 feet).

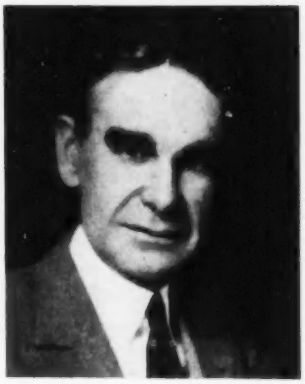
Brains Are Cheap

A NEW ELECTRONIC BRAIN which sells for less than $8000 and which takes up no more space than a 4-drawer filing cabinet has been placed on the market by the Computer Corporation of America, New York City.

This new Brain, more accurately termed an electronic analog computer and nicknamed "Ida" (for Integro-Diferential Analyzer), will be especially useful in engineering design since it eliminates the necessity of building costly experimental prototype models. The flight of an aeroplane built with a certain set of aerodynamic characteristics, for example, can be accurately simulated in the computer so that the plane can be flight tested before it leaves the drawing boards. In the same way similar dynamic situations can be reproduced and the behavior of various engineering factors in those situations can be determined on the computer.

Types of problems "Ida" can solve, include qualitative and quantitative dynamic studies in chemistry, mechanical engineering, aero-dynamics, nucleonics, thermodynamics, servo-analysis and network analysis. It solves linear differential equations with constant coefficients up to the eighth order. Eight initial conditions may be set into the problem.

Auxiliary equipment extends "Ida's" usefulness to the solution of differential equations of higher order than eight, differential equations with non-constant co-efficients and non-linear differential equations. Problems can be worked on either a real or modified time base in a matter of minutes.



THE EDWARD P. CONNELL AWARD for 1951 was made to Mr. Edward Whitney Miller, president of the Fellows Gear Shaper Co., in recognition of leadership displayed over the last 35 years in the development of sound principles in gear engineering. The American Gear Manufacturers Association, which selects the recipient for this award, is now headed by the following new officers: President—George H. McBride, Westinghouse Electric Corp.; Vice-President—S. L. Crawshaw, Western Gear Works; Treasurer—Louis B. Bond, Christian Machine Co.

Low Temperature Group Seeking Service Data

THE LOW TEMPERATURE GROUP OF the Joint Committee on Effect of Temperature on the Properties of Metals is very desirous of receiving information from engineers concerned with the design and/or operation of equipment, operating at temperatures below 0 deg F. Any one who wishes to contribute to this research is requested to send to A. L. Tarr, Engineer of the Research and Development Laboratories of the Laboratory Service Department of the Corps of Engineers, Ft. Belvoir, Va., data and information on this subject.

Specifically the Low Temperature Group desires service data on equipment which has been in successful operation at low temperatures. This data should include a brief description of the equipment, the operating temperature, the material of construction, including specifications where available, the type of service such as the pressure ratings and the length of time that the equipment has been in service.

Because a great deal of information can be gained from failures, the Low Temperature Group is particularly desirous of receiving data with

reference to equipment in low temperature service that has failed. Here again they desire a brief description of the equipment, the operating temperatures, the materials, type of service and length of service and a statement as to whether the failure was attributable to the low temperature or whether it was caused by other factors. A brief explanation is highly desirable.

The Committee is also desirous of knowing which of the following criteria are most significant: (A) past performance, (B) charpy impact, (C) impact tests other than charpy, (D) ductility as determined in a tension test, (E) Any other criteria. A brief explanation of the relative merits and significance of these criteria is desired.

All We Need Now Is the Rocket

WASHINGTON—By successfully taming concentrated liquid ozone, scientists have developed a fuel that may someday send rockets to the moon. Recent advances at Armour Research Foundation of Illinois Institute of Technology prove that concentrated liquid ozone can be handled safely.

More than just a rocket fuel, ozone has other valuable military and commercial applications. It can be decomposed directly to oxygen for submarine patrols and high altitude flying and is an ideal agent for water purification, air purification, and bleaching.

By demonstrating that ozone may be safely manufactured, scientists at the Foundation have opened the door for possible tonnage production.

During World War II, German scientists worked overtime on an ozone-propelled rocket designed to bombard New York City from launching platforms over 4,000 miles away, but were unable to discover the secret of handling liquid ozone without spontaneous-detonation.

By replacing oxygen tanks with containers of liquid ozone, both planes and submarines would gain additional space with no sacrifice in oxygen volume. Used for water purification, ozone is a powerful chemical that literally "burns up" impurities without leaving an unpleasant taste. Large cities, such as Philadelphia and Paris, and smaller communities, including Whiting and Hobart, Indiana, have used ozone water purification systems for years.

Ozone can readily be made by bombarding oxygen with a stream of high speed electrons.

A SIMPLE APPROVED SYSTEM applicable for anodizing aluminum under government specifications, as well as for civilian decorative and protective finishes, is now available to manufacturers and job shops. Equipment differs from the conventional type. There are no license fees or royalties involved. Chemicals may be purchased in open market. Inquiries should be addressed to Colonial Alloys Co., Philadelphia 29, Pa.

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A SIMPLE, INEXPENSIVE METHOD for determining the adhesion of commercial electro-deposited coatings has been recently developed by the National Bureau of Standards. The new technique involves the electrode-position of an adherent, mushroom-shaped nodule on the surface of the coating to act as a grip for the application of a detaching force. The force required to pull off the nodule, together with a portion of the coating, is then obtained on a spring balance in ordinary mechanical units.

•

IN RECOGNITION OF the increasing need for formal instruction in the field, a special two-week course in Photoelasticity will be offered by the Department of Mechanical Engineering at the Massachusetts Institute of Technology from 20 to 31 August. Designed primarily for the practicing engineer, with no previous knowledge of the subject, the course will emphasize the applications of the photoelastic method of stress analysis to industrial problems.

•

HAE COATING FOR MAGNESIUM, recently developed in the Pitman Dunn Laboratory at Frankford Arsenal as an Army Ordnance Corps project, resists abrasion, corrosion, galvanic action, has good dielectric strength and high melting point. Applied electrolytically in coats as thin as 0.0015 in., HAE provides excellent paint base, is hard enough to scratch glass or polish Rc65 steel. With wax coating, HAE has withstood 4,500 hours of salt spray with no corrosion. Heat tested magnesium panels have melted and flowed away from HAE coating which remained undamaged.

•

A COMPOSITE ENGINE for airplanes, which has both piston and jet power, has been developed in England. It is the Napier Nomad, and is actually a combination of a piston engine and a turbo-jet power plant. The gases for driving the turbine are produced by a highly supercharged piston engine and not by static combustion chambers. Details of the combination have not been revealed. Low fuel consumption is said to be an advantage. This means extra range for long-distance civil and military planes. Another new turbo-jet engine just revealed is the British Olympus which is said to have very low fuel consumption. There is a probability that this engine may be built in America by the Curtiss-Wright Corp. as part of the long-term agreement between the two companies for mutual engineering and technical aid.

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TO MEET RIGID METAL FINISH specifications economically, Elgin National Watch Company field trained representatives, are available for detailed study of specific fine finishing problems. Backed by the research and findings of the Elgin Laboratories, they will assist in the development of methods and techniques for maximum finishing efficiency without obligation.

•

THE STOKES VACUUM CALCULATOR will determine the needed pump capacity to evacuate a given volume to a specified vacuum in a given time, and the time required to reach a specified vacuum in a given volume with a pump whose capacity is known. It will be sent free on request to F. J. Stokes Machine Co., 5900 Tabor Road, Philadelphia 20, Pa.

•

ARMY ORDINANCE INVESTIGATORS have developed a new chemical corrosion inhibitor that will protect metal equipment by releasing a neutralizing vapor film. Heavy grease packing of rifles and other equipment may thus be eliminated.

•

RECENT INVESTIGATORS of the electrochemistry laboratory of the National Bureau of Science have shown that battery additives, preparations frequently sold with claims that they will rejuvenate dead batteries, have no effect on battery life or performance. Extensive laboratory tests simulating actual service conditions were made on a wide variety of commercial additives. The results show no significant difference between the batteries treated with these mixtures and similar untreated batteries used as controls.

Saved... By a Dow Corning Silicone

The pelt of many a mechanical rabbit has been saved by rewinding the motors that drive them with Dow Corning Silicone-(Class H) electrical insulation. That's a modern Aesop's fable* uncovered by our Atlanta office.

Here's the moral. When your private or corporate life depends upon continuous operation, specify Dow Corning Silicone insulated motors, generators, transformers or solenoids. The more it costs you to permit a motor to fail, the more imperative it is to prolong the life and to increase the reliability of that motor with Class H insulation made with Dow Corning Silicones.

For about twice the cost, you get ten times the life; for a few hundred dollars, you save several thousand dollars in lost production, man hours of labor, maintenance costs and repair bills.

Write today for more information on how you can keep ahead of the pack with Dow Corning Silicone (Class H) Insulation.

*** This fable can be and has been acted upon to save the less expendable hides of some of the most able electrical maintenance engineers.**

Send it TODAY

DOW CORNING CORPORATION, MIDLAND, MICHIGAN

Please send me more information including list of Class H motor repair shops and Class H motor manufacturers. **R-7**

Name _____ Title _____

Company _____

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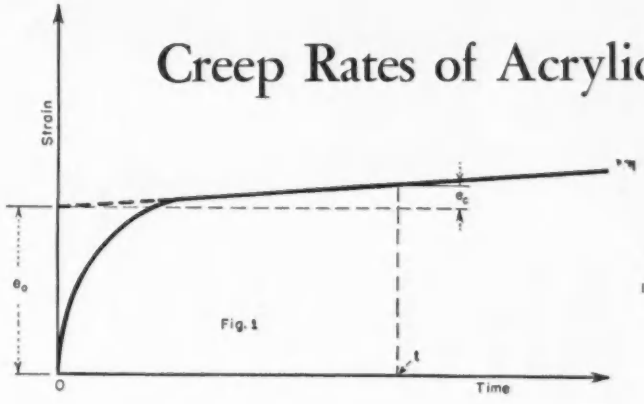
Creep Rates of Acrylic Plastics

JOSEPH MARIN
Pennsylvania State College



THERE ARE MANY PRODUCTS and structural parts made of plastics where it is important that the change in shape and deformation be restricted to specified limiting values, otherwise the part may become unserviceable. It is not always recognized that creep deformations may affect the utilization of many molded plastic products. In some cases, the creep deformations may become so large that fracture occurs. Examples are: fan blades subjected to centrifugal forces, material around metal inserts subjected to stress due to differential contraction, structural members subjected to direct load, and moldings which shrink due to high temperature.

Usual creep data based on simple tension tests are not always adequate since it is sometimes necessary to know the rate of creep under compression, torsion or bending stresses. For this purpose, the graphs in Figs. 2 through 5 provide data on the creep of Lucite on Plexiglas under various stresses for periods up to 1,000 hours or about 40 days. This duration may be satisfactory in some cases but there is still the problem of predicting what creep deformation will occur over longer periods.

For more extensive periods, an empirical relation for the creep in tension and compression has been found for both Lucite and Plexiglas. To calculate the creep strain e (inches per inch) after a period of time, the following equation is used:

$$e = e_o + e_c \qquad (1)$$

where e_o is the intercept strain and e_c the time dependent strain as illustrated in Fig. 1. Experimental data has shown that Eq (1) can be expressed as the function:

$$e = D\,s^m + B\,t\,s^n \qquad (2)$$

where s is the stress (psi) and t is the time (hours); D, m, B and n are constants. Table I gives specific experimental values for these constants.

From the creep data of Figs. 2 to 4, curves were plotted to show the creep rate as a function of the imposed stress. This is illustrated in Figs. 6 to 8.

Based on the equations above, a comparison of the creep rates in bending as given by theory and the actual values are shown in Fig. 9. Note that the largest percentage difference between the actual and theoretical values is about 20 percent, which represents very good agreement. This theory for predicting the creep deflections in bending is fully developed in the ASME Paper 50-A9-1.

Creep rate and stress relations for specimens of circular cross-section subjected to torsion are shown in Fig. 8. A satisfactory theoretical procedure for determining torsion creep rates over extended periods has not as yet been developed.

A correlation between the torsion and tension data was not possible due to the difference in materials tested. Torsion specimens were made of extruded rods while all others were machined from cast sheets which were annealed and stress relieved.

All data in these charts are based on tests under controlled conditions; the temperature was held to 77 F [±2 F] and the relative humidity maintained at 50 ±2 percent.

Table I—Values for the experimental Constants

	D	m	B	n
TENSION				
Plexiglas	1.01×10^{-9}	2.03	4.17×10^{-17}	3.08
Lucite	2.27×10^{-9}	1.98	3.78×10^{-18}	3.44
COMPRESSION				
Plexiglas	6.39×10^{-7}	1.20	4.99×10^{-15}	2.36
Lucite	2.36×10^{-7}	1.35	1.09×10^{-12}	1.81

Note: Specific values for Eq (2) with the units of s in psi, t in hours and e in inches per inch.

(continued on page 173)

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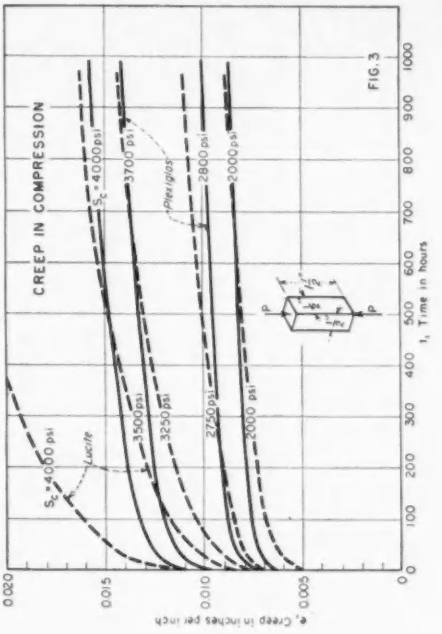
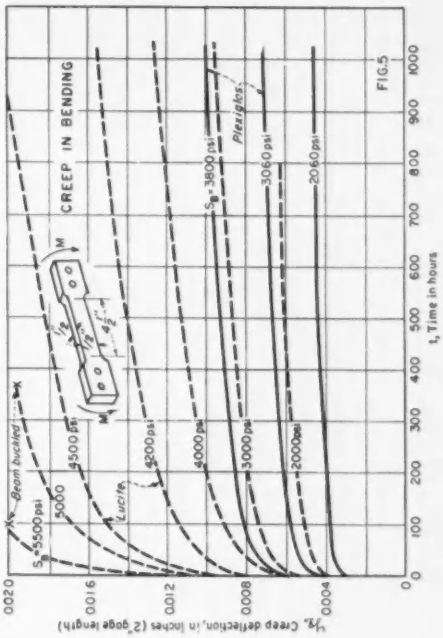
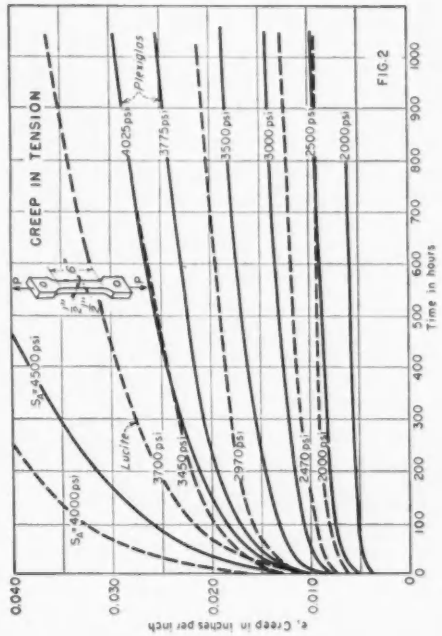
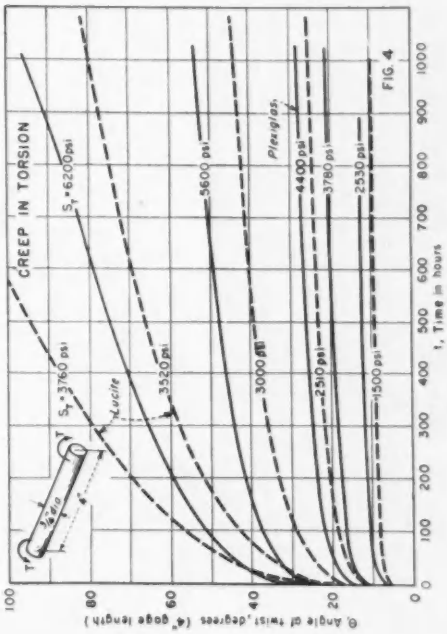
Creep Rate of Acrylic Plastics (continued)









(continued on page 175)

The metal coating that stretches like r-u-b-b-e-r

Keep this in mind about Armco ZINCGRIP Steel:

Its *special* hot-dip zinc coating works more like rubber than metal. It flows and s-t-r-e-t-c-h-e-s in brakes and dies. It takes as severe a draw as the base metal without flaking or peeling.

Compare this with conventional galvanized sheets. When these sheets are drawn or formed severely the coating invariably flakes or peels. This exposes the base metal to early rusting and failure.

Armco ZINCGRIP has another important advantage. Actual field tests show that its special zinc coating gives longer protection against rusting in atmospheric service than equal-weight coatings on regular galvanized sheets.

Even if you can't include this Armco Special-Purpose Steel in your present plans, it will pay you to have complete technical and merchandising information for the day when it is more plentiful.

More Scrap Means More Steel!

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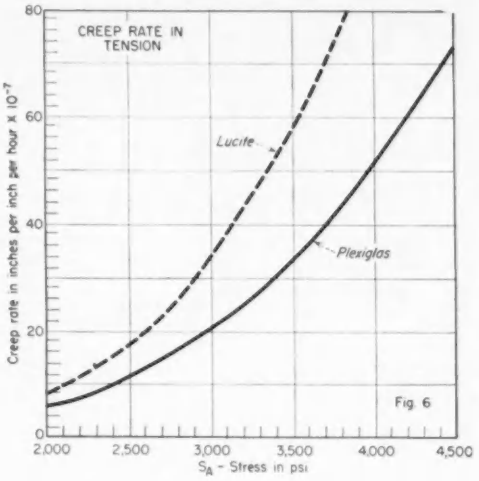
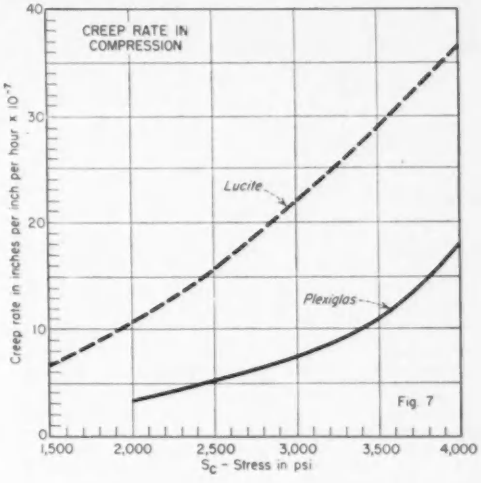
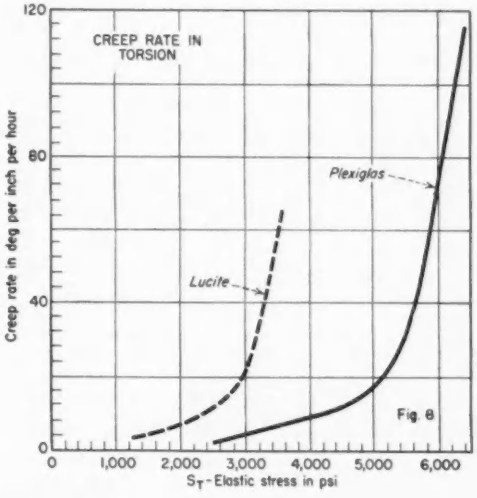
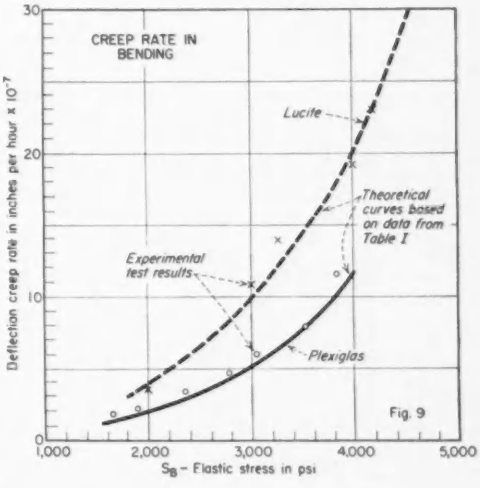
Creep Rate of Acrylic Plastics (continued)


CREEP RATE IN TENSION
Creep rate in inches per inch per hour x 10⁻⁷
Lucite
Plexiglas
Fig. 6
2,000 2,500 3,000 3,500 4,000 4,500
S_A - Stress in psi


CREEP RATE IN COMPRESSION
Creep rate in inches per inch per hour x 10⁻⁷
Lucite
Plexiglas
Fig. 7
1,500 2,000 2,500 3,000 3,500 4,000
S_C - Stress in psi


CREEP RATE IN TORSION
Creep rate in deg per inch per hour
Plexiglas
Lucite
Fig. 8
0 1,000 2,000 3,000 4,000 5,000 6,000
S_T - Elastic stress in psi


CREEP RATE IN BENDING
Deflection creep rate in inches per hour x 10⁻⁷
Lucite
Theoretical curves based on data from Table I
Experimental test results
Plexiglas
Fig. 9
1,000 2,000 3,000 4,000 5,000
S_B - Elastic stress in psi

EXAMPLE:

Structural member 2 ft. long made of Lucite is to be subjected to an axial tensile load of 500 lb. at a maximum temperature condition of 100 F. Find the cross-sectional area required for an estimated life of five years based on:

(a) An ultimate strength of 6000 psi (short time) with a safety factor of 3.

(b) A creep-rupture strength of 3000 psi at five years and having a factor of safety of 2.

(c) A maximum allowable creep of 0.025 in. per in.

SOLUTION:

(a) Based on the short-time strength, the allowable stress is 6000/3 or 2000 psi.

(b) Using the long-time rupture strength value, the allowable stress is 3000/2 or 1500 psi.

(c) With the allowable creep deformation, the stress can be calculated from Eq. (2). This gives, s of 625 psi.

The governing value of the working stress will be the smallest of the three, or 625 psi. The required area is bound to be 500/625 or 0.80 sq. in.

Magnetic Particle and Hysteresis Clutches For Servo Systems

Two entirely different types of clutches and brakes have been developed for military and industrial servo control systems. These are dry magnetic particle units and hysteresis type clutches and brakes.

Magnetic fluid and dry particle bi-directional clutch actuators have been attractive since inception for closed loop rate-displacement position servo systems. Favorable space envelope, low controlling power and speed of response together with excellent torque to inertia ratios give the servo designer valuable tools to work with.

The principle limitations appear to be:

1. Capacity to dissipate power in continuous duty cycles in excess of 200 hr without a percentage of torque fade.
2. For maximum operational life, low driving speeds are desirable. Placing the actuator at the low speed high torque side of the system shows marked advantages.
3. Torque repeatability for given current impressed shows a fairly wide loop—on the order of ±15 percent.
4. Unenergized residual torque is essentially balanced mechanically in bi-directional configurations. However, input speeds are limited, thereby, as the differential speed between clutching members of the unenergized clutch is 2:1.
5. Sensitivity to ambient change when unenergized; a 16 oz in. torque single clutch will develop a residual of 1.85 oz in. at —10 F with input speed of 450 rpm.
6. Close fabrication tolerances and assembly techniques are required for series production.

The unforeseen advantages of the fluid magnetic actuators are:

1. No backlash (for life) at output of bi-directional units due to tooth pressure established by residual torques.
2. No shock loading of teeth in associated gear trains. Although accelerations are extremely rapid, there is no shock loading as accelerations are always proportional to magnetic field rise. This characteristic permits gear tooth loading far in excess of normal.

Proper consideration of these factors in the application of FM torque controllers makes possible extremely tight servos, useful from both functional and service aspects.

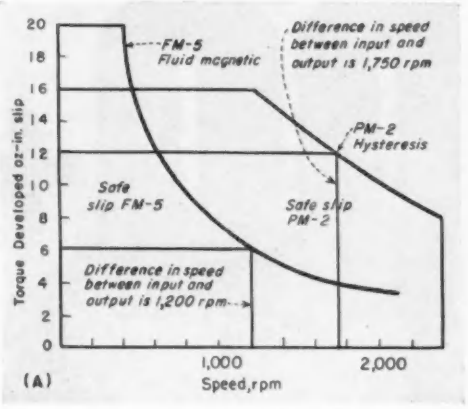
Industrial field experience with fluid magnetic clutches indicates the relatively short maintenance-free service life, torque variation, etc. limited the FM clutch application for industrial work. To fill this gap, a hysteresis clutch has been designed.

The PM hysteresis clutch is an interesting device, providing the inherent advantages of the FM proportional torque controllers. These clutches are finding important application as radio antenna actuators. Standard bi-directional PM-2TG hysteresis actuators, employed between the drive motor and radar antenna transmission, provide important advantages over systems used in the past.

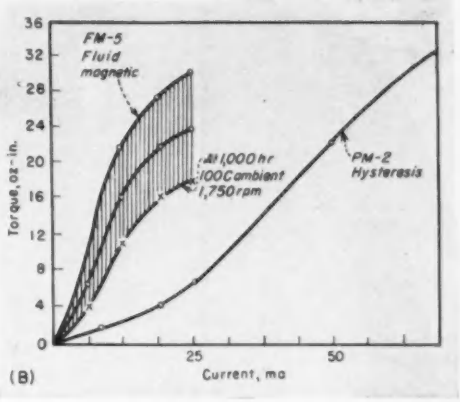
Size of bi-directional hysteresis clutch Model PM-2TG at the left is compared with clutch Model PM-2 at the right

By use of twin clutches of the PM hysteresis type, response and sensitivity for tracking are vastly improved for given control signal amplitude. It is not necessary to control the inertia of the drive motor for rapid reversals and accelerations. The motor is continuously rotating at high speed in its best torque vs rpm range and is not required to handle a starting load. The inertia of clutch output driving members is, in most cases, less than motor load by a factor of 50 to 100. The continuously rotating input or driver members and the drive motor inertia at speed provide high orders of stored energy or flywheel effect.

Operating Characteristics of	
Characteristic	Hysteresis Clutches Model PM—2TG
Max Torque	2, 4, and 10 lb
Standard output gearing	1:15, 2:1, and 5:1
Max rating	1/8 hp
Continuous max power dissipation	15 watts
Intermittant power dissipation	100 percent (30 min)
Max input speed (recommended)	4,000 rpm
Torque to inertia ratio (acceleration)	12,200 rads/sec^2
Input member inertia	695 x 10^{-6} slug-ft^2
Output member inertia	32 x 10^{-6} slug-ft^2
Response time	50 millisec
Size	6 1/4 x 5 3/8 x 2 7/8
Weight	8 lb



ALLOWABLE AVERAGE CONTINUOUS SLIP torque for typical fluid magnetic and hysteresis clutches.



TORQUE CURRENT CHARACTERISTICS of fluid magnetic and hysteresis clutches for servo control systems.

No mechanical friction members for torque generation are employed. These actuators are relatively free from the influence of environment. The PM-2TG actuator has a rated power dissipation of 100 percent of its rating for ½ hr, and is capable of continuously dissipating 15 percent of its maximum rating.

The PM-2TG has found significant applications for groundborne Radar Antenna tracking systems. However, space and weight factors cannot compare with the FM units at this time.

In the industrial field, PM clutches have rapidly shown a wide margin of advantage for tension controls, and torque limiting devices such as nut running, tapping, die cutting machinery and spindle control on automatic machine tools. PM devices are also being employed as precision controllers (plus or minus 1 percent error) for dynamometers and speed controllers for generator alternator equipment.

Significant data on the performance characteristics and the physical dimensions of several different models of both magnetic particle and hysteresis type clutches are given in the accompanying tables and charts.

Duncan & Bayley, 785 Hertel Ave., Buffalo, N. Y.

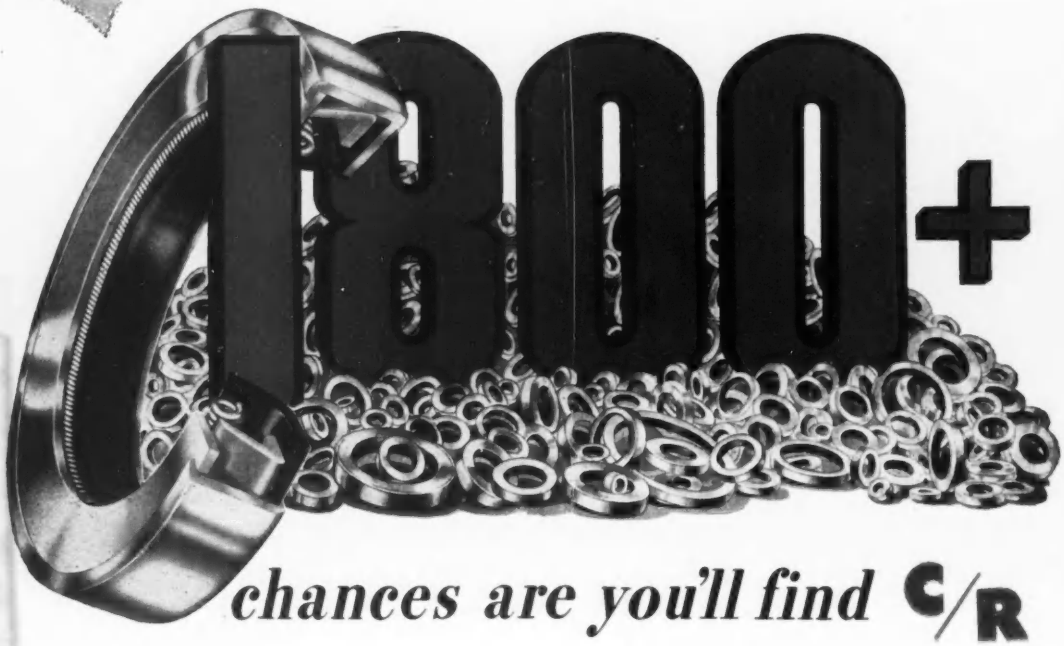
Hysteresis and Dry Particle Fluid Magnetic Clutches

	Type of Clutch or Brake			
Hysteresis Clutches and Brakes	Dry Particle, Fluid Magnetic, Clutches and Brakes	Dry Particle, Fluid Magnetic, Clutches and Brakes		
PM-2C, PM-2B, PM-2CB	FM5, FM55, FM5B, FM5TB	FM-5T	FM5-TG	FM-5T Brake
36 oz	16 oz	16 oz static	14 lb-in.	12 oz-in.
		1:1	14 5:1	1:1
1/6 hp	0 028 hp	0 028 hp	0 028 hp	0 028 hp
15 watts	4 oz-in. at 1,750 rpm	4 oz-in. at 1,750 rpm	4 oz-in. at 1,750 rpm	4 oz-in. at 1,750 rpm
100 percent (1 hr)				
5,000 rpm	1,750 rpm	1,750 rpm	1,750 rpm	1,750 rpm
12,200 rads/sec^2	480,000 rads/sec^2	135,000 rad/sec^2	21,600 rad/sec^2	
308 2 x 10^{-6} slug-ft^2	8 x 10^{-6} slug-ft^2			
12 8 x 10^{-6} slug-ft^2	1 7 x 10^{-7} slug-ft^2			
38 millisec	96 percent	78 percent	75 percent	75 percent
4 3/4 shaft to shaft x 2 1/2	3 844 x 1 1/2 x 1 1/2	1 3/4 x 2 5/8 x 4	2 x 2 5/8 x 4 1/4	
30 oz	8 oz (FM-55)	14 oz	16 oz	18 oz

CONTINUED ON PAGE 179

C/R

PICK AN APPLICATION



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P. S. More motor vehicles, farm implements, road machinery and industrial machines are equipped with C/R Oil Seals than with any similar device.

Chicago Rawhide engineering service is always available for the solution of your particular sealing problems.

ENGINEERS: We will be pleased to send you engineering data on "Perfect" Oil Seals on receipt of your written request.

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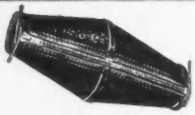
1299 Elston Avenue **OIL SEAL DIVISION** Chicago 22, Illinois



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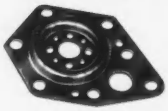

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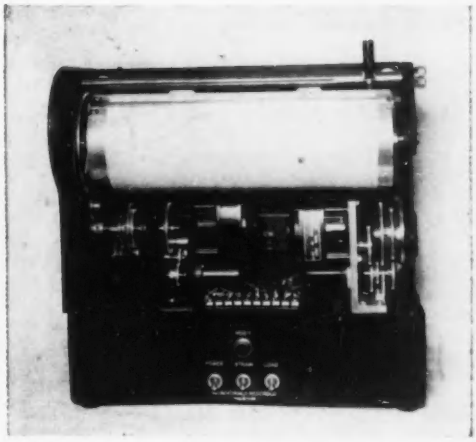
"X-Y" Type Recorder Is Self-Contained

A strip-chart recorder of the "X-Y" type for plotting automatically on rectangular coordinates the simultaneous relationship between any two variables that can be made to actuate Microformers is self-contained and portable.

The recorder, identified as the MD-2, is similar in size and appearance to other models designed for attachment to Baldwin B-T-E testing machines. It can be used with some types of testing machines having mechanical loading and weighing systems. It can also be used with any testing machine in which hydrostatic pressure in either the loading or weighing system is proportional to load applied to the specimen. For these applications separate Bourdon tube units are available for permanent attachment to the hydraulic system of each testing machine with which the recorder may be used. These are connected with the recorder by a cable having polarized plugs. Any of 25 or more standard Baldwin Microformer Type strain followers can be used with the recorder.

Microformers are miniature variable transformers having usable core movements of 0.120 in. Displacement of the core of an external, sensing Microformer upsets the balance of a self-balancing bridge of which it and the recorder Microformer are a part. The unbalanced signal is amplified by an electronic circuit and drives a servomotor. This moves the core of the recorder Microformer to the same position as the external core, thus reestablishing electrical balance, and operating the recorder drum.

Sensing Microformer core movements of 0.03 in. and 0.06 in. can produce full scale (10 in.) displacement of the stylus, and core movements of 0.03 in., 0.06 in. and 0.120 in. can produce drum rotation of 10 in. Each of the recording elements, when used with an external Microformer of standard precision type, has a recording sensitivity of 0.000015 in. Movement of the external Microformer core can be recorded to an accuracy within 0.2 percent of the recorder scale range. Full scale 10 in. response of the stylus across the chart can be obtained in approximately 6 sec on the full scale-range, and in approximately 3 sec on the half scale-range. Full scale 10 in. rotation of the chart can be obtained in 20 sec on all three ranges. Higher speeds may be obtained on special order. The recorder dimensions are approximately 14 by 10 by 13 in. and it weighs 50 lb.



MOTOR DRIVE AT LEFT rotates drum. One on right operates stylus. Recorder Microformers are under motors.

Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa.

Precision Potentiometer Has All-Metal Construction

All-metal construction, to retain the accurate mechanical tolerances which are necessary when precision potentiometers are used with precision gearing, is one of several features of a new precision potentiometer, designated as Type 746. The Type 746 potentiometer is designed to permit the ganging of up to 20 units on a single shaft, the easy removal and replacement of units within a ganged assembly, and a simple, more accurate means of phasing each unit without disassembly. The latter two features are particularly advantageous in experimental work where circuit elements are changed periodically. Special plug-in units are also available.

Of small size (1.75 in. diameter), the Type 746 is custom-built to meet the requirements of specific applications. General specifications cover both linear and nonlinear windings over a range of resistances up to 100,000 ohms, and guaranteed accuracy of 0.5 percent linear and 1 percent nonlinear based on over-all resistance. Torque is only 1.5 oz-in. Service life is 1,000,000 cycles.

Fairchild Camera and Instrument Corp., 88-06 Van Wyck Blvd., Jamaica, N. Y.

CONTINUED ON PAGE 180

Eye Bolt Is Load-Centering

Designed to carry weights 10 times heavier than possible with a conventional eye bolt, an improved eye bolt achieves its great strength through its load-centering feature. The eye pivots, permitting the weight to center.

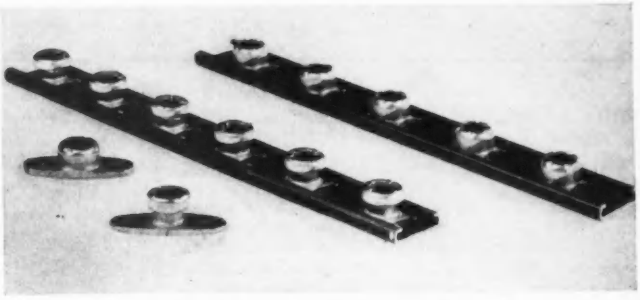
Made of high-grade steel, the eye bolts are ductile and tough, providing reliable safety factors under intermittent strains and shock loads. Light in weight and precisely balanced, they are easy to install and use. Bolts are replaceable, thus giving extra life. No haphazard or makeshift rigs need be used; hence, serious accidents to men and equipment are prevented. Standard models are available in bolt sizes of $\frac{1}{2}$, $\frac{5}{8}$, $\frac{7}{8}$ and 1 in. USS threads. Special sizes and SAE threads also are made to order.

Further details regarding sizes and application are available from the manufacturer upon written request.

Ribert H. Froom & Co., 1738 W. 81st St., Los Angeles 47, Calif.

Gang Channel and Anchor Nuts Save Weight

Two designs in gang channel and anchor nuts are said to permit a saving in weight ranging from 25 to 30 percent with no sacrifice in strength, and are thus especially suitable for airframes and components. With the same high strength of previous designs, but with less metal used, the new gang channel nut (new strip at left compares with old strip at right) is 30 percent lighter and the new anchor or plate nut (new nut in left foreground compares with old nut behind it) is 25 percent lighter than similar fasteners now commonly used.



The parts are manufactured in conformance with Specification AN-366, and are approved for use by aircraft manufacturers. The designs are now available for applications where heavier types of nuts have been used, and both are directly interchangeable with other AN parts, since they are designed within the same over-all envelope dimensions. A red elastic locking collar assures re-usability, keeps bolt and nut threads rust-free, and seals against liquid seepage. The insert provides a constant self-locking torque, that simplifies accurate bolt loading, and, at the same time, protects the fastenings against vibration, impact, and shock.

The gang channel strips as supplied by the manufacturer are assembled in 24S-T4 aluminum alloy channels that are blue anodized for identification purposes. Even though the channels are designed to retain the nuts in proper position over the bolts, sufficient play is present to allow for reasonable misalignment.

Complete details of the new lightweight channel and anchor nuts can be obtained from the manufacturer with no obligation upon request.

Elastic Stop Nut Corp. of America, 2330 Vauxhall Rd., Union, N. J.

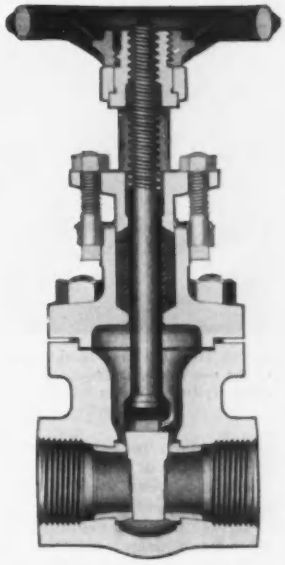
CONTINUED ON PAGE 182

To save yourself time and trouble... Specify piping from your CRANE Catalog

Suppose you're writing piping specs for this *Fuel Oil Pumping, Heating, and Transfer Unit.* You greatly simplify your job when you reach for your Crane Catalog. In it you'll find—and quickly—an unequaled selection of valves, fittings, pipe and accessories.

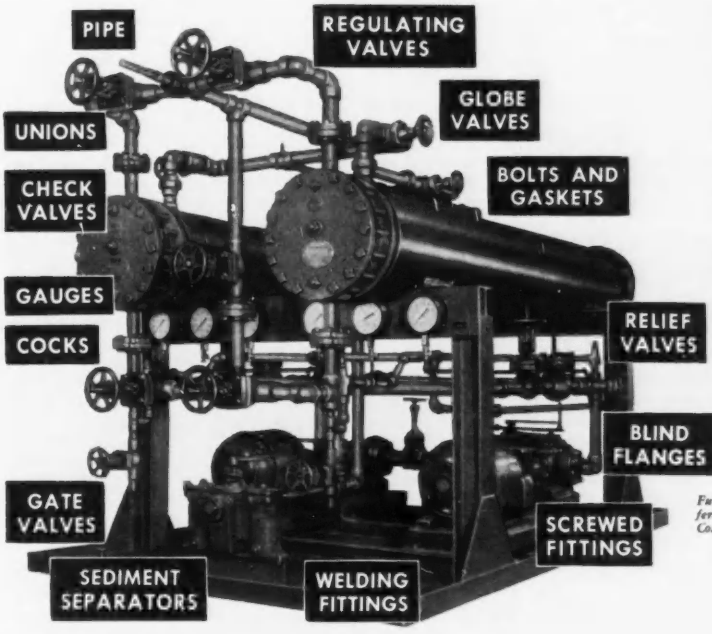
Information about every item is complete. When you check on a valve or fitting, you get all its dimensions; tabulated pressure and temperature ratings; design, material, and construction details; and a full listing of service recommendations. There's an abundance, too, of general engineering data helpful in designing piping systems.

Today, when work loads on machinery are heavier than ever, the name Crane gives your product added value. For experienced buyers know that Crane Quality in piping materials means utmost dependability.



FOR OIL OR OIL VAPOR *services at temperatures over 500° F. and up to 1000° F., and for most corrosive and unrefined oils regardless of temperatures, Crane recommends No. 3607X 600-Pound Small Steel Wedge Gate Valves. Exelloy to Exelloy Trim. Bolted bonnet. O.S.&Y. Screwed, socket-welding, or flanged ends. Sizes: ½ to 2-in. See your Crane No. 49 Catalog, p. 225.*

YOU SPECIFY IT... CRANE SUPPLIES IT...
PIPING EQUIPMENT FOR EVERY DESIGN



Fuel Oil Pumping, Heating, and Transfer Unit by Enterprise Heat and Power Co., Chicago, Ill.

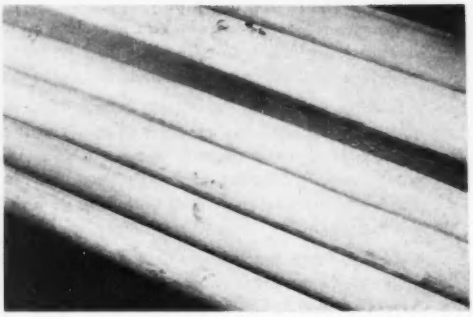
CRANE CO.

General Offices:
836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

Now Stainless Steel Can be Hot Worked

CONE TEST for hot forgeability. The two pancakes shown are of the exact same analysis . . . except that the one on the left, relatively free of cracks and tears, contains cerium.



PRACTICAL EFFECTS OF CERIUM are seem in these bars of hot rolled stainless steel type 316. Before the use of cerium, it was virtually impossible to hot roll this alloy successfully.

High-alloy, corrosion resistant, heat resisting stainless steels that can be hot worked have recently been developed. Use of the elements cerium and lanthanum transforms ferrous alloys containing nickel and one or more of the elements chromium, molybdenum, cobalt, copper, tungsten, silicon, manganese, columbium, and vanadium from materials with limited hot workability to alloys that can readily be hot forged or rolled into sheets, bars, and tubes.

Alloys included in the new cerium-bearing alloy range and patented as such include AISI Types 309, 310, 316, 317, and 330, as well as Carpenter Stainless 20 and Carpenter austenitic valve steels. However, the development applies not only to ferrous alloys containing more than 50 percent iron but also to nonferrous alloys containing little or no iron.

Heretofore, a principal obstacle to the full utilization of the advantages offered by these alloys has been the difficulty or practical impossibility of forging and rolling them into desirable shapes like sheets, rods and tubes. While many efforts have been made to solve this problem, the obstacle has existed throughout the industry for years and has restricted the uses of these alloys in certain applications involving high temperatures, stresses and pressures. For example, certain alloys containing nickel, chromium, molybdenum and copper which provided satisfactory corrosion resistance could be cast satisfactorily—but when hot working was attempted, the resulting bars were so badly torn or cracked that they were unusable. This has limited the use of these desirable alloys to those fields in which the casting process could be used.

Heretofore, the chief uses of cerium and its compounds have been found in cored carbon for flaming arcs, in flints for cigarette lighters, and in the ceramic industry. The principal source of cerium and lanthanum is monazite sand. The supply of cerium and lanthanum recently has received a boost because of the intense interest in certain heavy elements so vital to the production of atomic energy. Some of these heavy elements can be obtained from thorium, which is found in some monazite sands.

Pure cerium or pure lanthanum may be used separately, but combinations of the two metals within certain minimum and maximum proportions have been found effective. The combinations are found in misch metal, the major part of which consists of cerium and lanthanum.

The nickel content of any of the alloys of this development determines the minimum and maximum allowable ranges of cerium and lanthanum that will produce hot workability. It was further discovered that as the nickel content increases in any of the alloys, the allowable range of cerium and lanthanum which can be used to promote workability, is narrowed.

It is felt that the development can increase the use of high-alloy, corrosion resistant, heat resisting steels formerly found to be impractical because of limited hot workability. Carpenter is now engaged in the application of cerium to many of these steels but it is also interested in the broader industry aspect of increasing the use and production of many other steels strategic to the defense efforts of the entire nation.

Carpenter Steel Co., Reading, Pa.

DEVELOPED IN ANSWER TO THE NEED FOR an increased range of resistance as well as a lower temperature coefficient, new resistors containing boron possess greater stability with a lower noise level. With small aging and low temperature coefficient of 20 parts per million per degree Centigrade, the new resistors are available in $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$, 1 and 2 watt sizes. Wilkor Products, Inc., 2882 Detroit Ave., Cleveland 13, Ohio.

TENSULATED MINIATURE WIRES so small that 350 wires pass through half a paper clip, are produced by an exclusive process; this makes it practical to provide low-voltage, hookup wires, shielded lead wires, and small flexible cables that are tailor-made to suit the special needs of those who use them. Each wire consists of four strands of No. 40 copper wire. Tensolite Insulated Wire Co., Tarrytown, N. Y.

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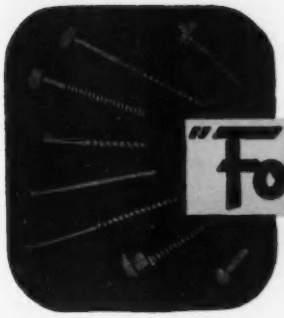


"Formbrite"

GOOD NEWS for those who use Cold Heading Wire

THIS MAY BE THE FIRST TIME you've heard of "Formbrite." But to those who fabricated the millions of pounds we've produced in the past year, Formbrite represents a long forward stride in the metallurgical development of Cold Heading Wire.

The name "Formbrite" designates a special process of rolling or drawing, plus a special heat treatment which imparts a superfine grain to copper-base metal. At present Formbrite is produced only in certain brass alloys.

The advantages? Formbrite Cold Heading Wire is bright, clean, strong and "springy"—yet possesses a degree of workable ductility unlike any wire you've seen of equal strength and hardness. That's what makes it so desirable for rivets, wood screws, machine screws and a host of other cold upset products.

Where parts are to be polished or plated, fine-grained Formbrite offers definite money-saving advantages on buffing, polishing and tumbling operations. Moreover, Formbrite Cold Heading Wire is supplied in *one* temper, resulting in simplified stocks and inventory.

Formbrite is produced in the form of sheet, strip, rod, wire and seamless tube—at no increase in price. For deep-drawn polished or plated parts, it's been nothing short of sensational. Want to compare Formbrite with ordinary drawing brass in your own polishing room? Then write for a kit of two sample cups—plus additional information about Formbrite. Address The American Brass Company, General Offices, Waterbury 20, Connecticut. B1100

Formbrite is a trade mark of The American Brass Company designating copper-base alloys of exceptionally fine grain, combining unusual polishing characteristics with strength and hardness, plus excellent ductility.

ANACONDA

the name to remember in

COPPER·BRASS·BRONZE

Locknut Has Nylon Locking Medium

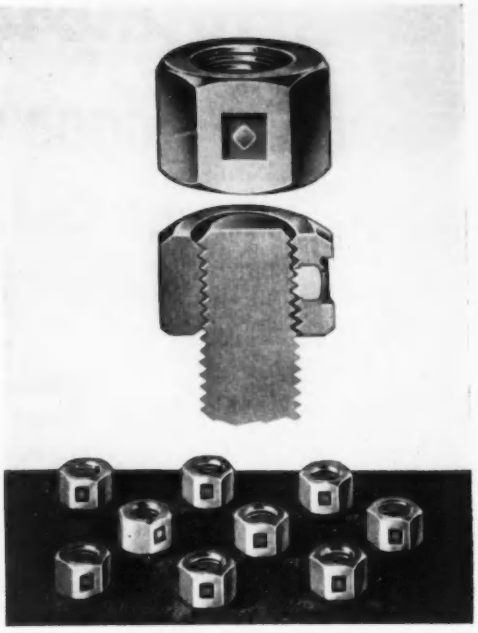
Etruded nylon is used as the locking medium in a one piece, prevailing torque type of self-locking nut, which is usually furnished double-chamfered.

The design of the nut permits installation from either end and provides positive locking action in any position. Low installation torque saves time and lock washers and subsequent double assembly, handling, and stocking problems are eliminated.

Nylok Type "E" Locknut is cold-forged to provide added strength to the body and threads and to save critical materials. The locking medium is a nylon plug insert in one of the hex faces on the nut midway between top and bottom. The plug projects slightly beyond the crest of the thread, and when the nut is run down on a bolt, the nylon is compressed but not cut by the bolt threads. Its springlike action grips threads tightly and sets up a counterthrust, creating strong metal-to-metal wedging of bolt and nut threads.

When a nut is removed, the resiliency of nylon makes the locking element seek to return to its original shape giving great re-usability. This also makes it possible to lock the nut in any position on a bolt—seating is unnecessary. Because of nylon's elasticity, the nuts work effectively on threads of varying pitch diameters. They give smooth torque and will not gall or damage bolt threads.

The nylon used as the locking medium has high tensile strength and retains this characteristic at low temperatures —does not become brittle at —400 F and is unaffected by cold even after continuous exposure to moisture. It also withstands continuous temperatures up to 250 F and reheating does not lessen its re-usability. The insert has a low moisture rate and capacity, so the locking action is unaffected by use in water. Commercial solvents—alcohols, gasoline, oil or boiling 40 percent caustic soda—do not affect the insert. It will not dry-out-or shrink with age, and fungus does not affect it. Nylok Locknuts are available at the present time in both the American standard light (E-6)



and also the American standard light-thick (E-7) series in sizes $\frac{1}{4}$ through $\frac{3}{8}$ inches. Further details can be obtained from the manufacturer.

Townsend Co., New Brighton, Pa.

Ultra-Violet Lamp For Inspection

High-intensity long-wave ultra-violet lamps bring to industry an efficient method of applying the principles of fluorescence to inspection and laboratory analysis, as the differences in fluorescent coloring are almost a sure indication of a variation in the composition, source, or history of any two or more substances.

Underwriters' Laboratories approved, Blak-Ray lamps are equipped with a self-filtering "black-light-blue" tube that allows the long-wave ultraviolet rays (3,660 angstrom units) to pass through, but filters out the undesirable rays in the visible portion of the spectrum. No additional filters are required, and the cool-operating tubes will last for 2,000 to 3,000 hr. Recommended for use at low light-levels, they do not, according to the manufacturer, require as great a degree of darkness as lamps using separate filters.

Available in 4, 8, 15, 30, 40 and 80 watt sizes, the fixture is unusual in that it may be rested on a flat surface, mounted flush to wall or ceiling, or hung from brackets. The 4 and 8 watt sizes have a special trunnion type ball that allows them to be tilted to any position within a 180 degree plane of the mounting surface. These models may also be used as portable inspection lights, as they weigh only $1\frac{3}{4}$ lb and have an over-all dimension of $3\frac{1}{4}$ x 4 x $6\frac{1}{2}$ inches. All sizes are equipped with Spectral Finish aluminum reflectors that mean 2 to 3 times the reflected ultra violet intensity of other materials.

The Blak-Ray lamps are useful in many phases of industry and research, including food processing, photography, textiles, and dyestuffs. Additional information on ultra-violet light and its possible applications in the various industrial fields can be obtained without charge by writing to the manufacturer. Technical assistance with a specific problem on the use or installation of the Blak-Ray Lamps is also available upon written request.

Ultra-Violet Products Inc., So. Pasadena, Calif.

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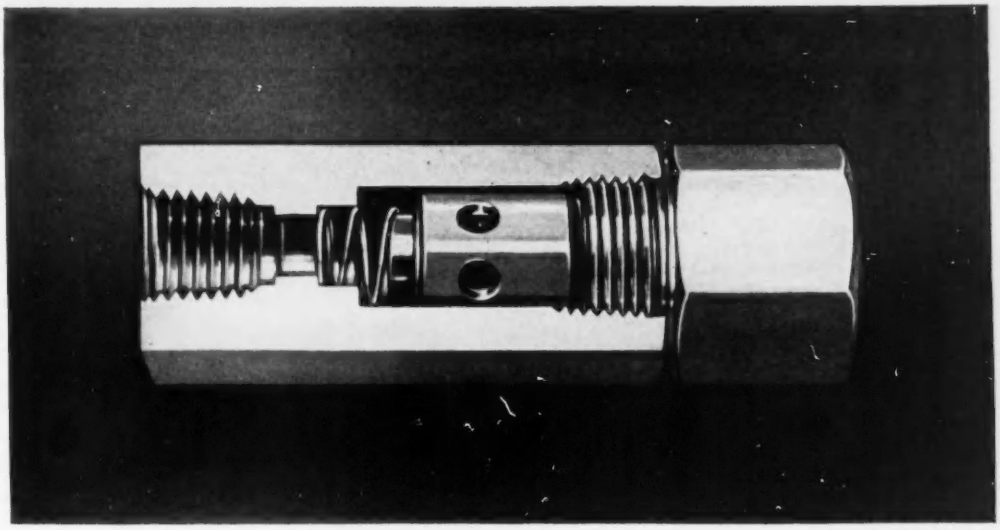


Soft Seat Check Valve

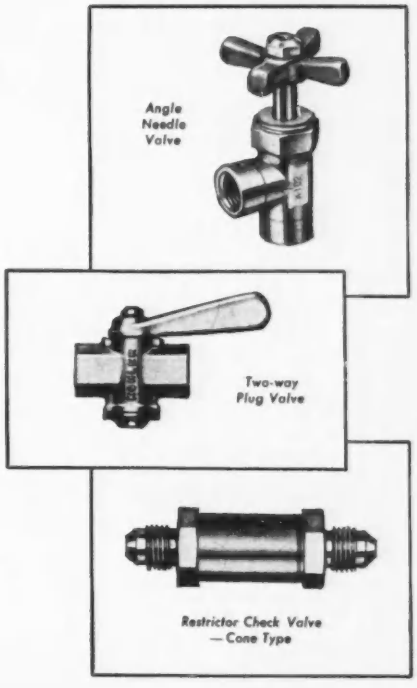
KOHLER *Precision Parts*

AIRCRAFT • INDUSTRIAL • AUTOMOTIVE

KOHLER PRECISION PARTS are used by manufacturers of Diesel engines, automobiles, trucks, tractors, jet engines, military, commercial and private aircraft, and for agricultural and industrial test equipment.

With an organization experienced and skilled in precision workmanship, Kohler maintains full facilities for forging, casting, machining, anodizing.

Kohler engineers will develop precision valves and fittings for volume production to meet special applications. Write for a catalog and send your specifications or requirements.



KOHLER CO., KOHLER, WISCONSIN. ESTABLISHED 1873

KOHLER OF KOHLER

PLUMBING FIXTURES • HEATING EQUIPMENT

ELECTRIC PLANTS • AIR-COOLED ENGINES • PRECISION PARTS

Liquid-Tight Fittings Connect Flexible Conduit

Liquid- and vapor-tight positive ground fittings are used to connect synthetic covered flexible metallic conduit. This type of conduit and fitting is recommended where water, oil, chemicals, grease, dirt, corrosive fumes, etc., are present or where small movement and hard-to-get-at places are all factors to be dealt with.

Besides being vapor- and liquid-tight, these Vap-Oil-Tite fittings have an unusual feature in the threaded bushing or ferrule that threads into the spiral between the convolutions of metal core of the conduit, thus insuring a foolproof, positive ground. This bushing also makes it unnecessary to burr the ends of the metal core after cutting because of a collar that covers the rough edges.

The fittings and bodies are furnished in sizes from $\frac{3}{8}$ in. to 2 in. Complete in themselves, they require no other parts or materials to make sound leakproof connections. A wrench or a pair of pliers is needed.

Suggested uses: for wiring equipment in the machine tool, food processing, brewing, chemical, petroleum, paint, plastic and utility industries, as well as outdoor uses on cranes, and many types of mobile equipment.

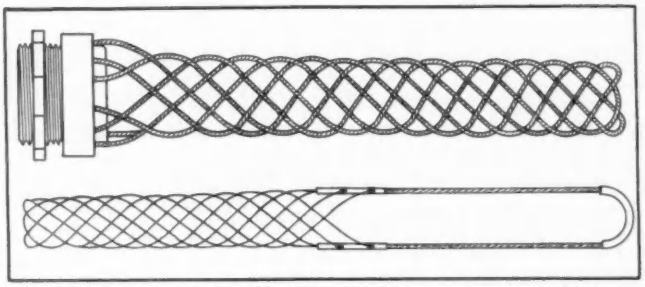
The illustration shown above indicates "the wide range of fittings" that are now available to fit various possible applications. Descriptive literature and further details can be obtained from the manufacturer without obligation.

Simplet Electric Co., 3602 Potomac Ave., Chicago 51, Ill.

Flexible Type Strain Relief and Bus Drop Grips

Strain relief and bus drop grips have advantages over other methods of supporting bus drop or power duct cable because they exert a longitudinally distributed load throughout the length of the grip and are completely flexible, easy to install, and inexpensive.

The grips operate on the simple geometrical theorem that the shortest distance between two points is a straight line. When a grip is slipped over a cable and a force exerted on it, the wires of the mesh try to straighten out. However, the inertia of the column holds the mesh back, and the result of the two forces is a powerful grip on the cable by the straining wires of the mesh. All grips are made with the varied mesh which causes the grip to exert a longitudinally distributed load throughout its length. The illustrations show drawings of the strain relief and bus drop grips. They are usually made of galvanized steel strand but may be obtained in bright bronze or stainless steel. Strain relief grips come with neoprene seals inserted in the fitting to prevent seepage of grease and any other fluids which might impair the performance.



STRAIN RELIEF GRIP (upper) has an iron pipe fitting; the bus drop grip (lower) has an aluminum eye and stem for use with springs. Both models come in different sizes.

Kellems Co., 15 Williams St., Stonington, Conn.

CONTINUED ON PAGE 188

No cause for alarm*

Drop it... scrape it... bump it... sit on it! But don't concern yourself about its welfare! This luggage is made with a *Fiberglas reinforcement!*

Created by H. Koch & Sons, San Francisco, this Fiberglas-reinforced luggage is lighter than aluminum . . . stronger than steel. Molded-in colors are rainbow-bright and stay that way through years of the toughest travel. In fact, the Association of Baggage Traffic Managers has recommended it as the only baggage that can be safely checked *without a protective cover!*

Alert manufacturers are using this rugged new material to make a host of civilian and military products, such as washing machine parts, fishing rods, boats, furniture, tote boxes, military instrument cases, and aircraft components . . . wherever light weight, durability, resistance to age, weather, water, acids and oils are a *must.*

Investigate Fiberglas reinforcements for yourself. For further details write: Owens-Corning Fiberglas Corporation, Reinforced Plastics Division, Department 807, 16 East 56th Street, New York 22, N. Y.

IT'S PLASTIC, REINFORCED WITH OWENS-CORNING FIBERGLAS *Yarns*

"Fiberglas" is the trademark (Reg. U. S. Pat. Off.) of Owens-Corning Fiberglas Corporation for a variety of products made of or with fibrous glass.

FIBERGLAS IS IN YOUR LIFE... FOR GOOD!

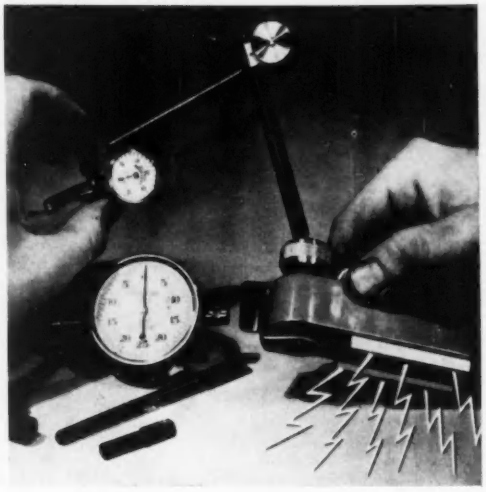
Magnetic Base Holder Has 100 Lb Pull

A portable magnetic-base indicator holder attaches with a 100 lb pull to flat or curved surfaces for holding securely and precisionally all dial type indicators. The unit is equipped with a fingertip release for removal or positioning the holder without jarring the indicator being held.

The set, which includes accessories for accommodating all stem-type, hole-type and lug-back indicators, consists of (1) the magnetic base holder constructed of non-breakable molded plastic, finished $1\frac{1}{4}$ in. wide, 4 in. long and $1\frac{5}{8}$ in. high. Steel parallel ribs $2\frac{1}{4}$ by $\frac{1}{4}$ by $\frac{1}{4}$ in. provide the magnetic contact surface on the bottom of the unit. Also on the bottom is the magnet release, helical design, which operates by a fingertip lever. At the top end of the unit is a post 4 in. in length with ball stem, socket and lock nut construction. (2) Adaptor for $\frac{5}{32}$ in. stud-type indicators. (3) Universal swivel adaptor with $\frac{1}{4}$ and $\frac{5}{16}$ in. grip lock holes. (4) Sweep arms, one $\frac{1}{4}$ and $\frac{5}{16}$ in diameters and one $\frac{1}{4}$ and $\frac{7}{32}$ in. diameters. (5) Bracket arm for lug back indicators with $\frac{3}{16}$ in. and $\frac{1}{4}$ in. holes.

With this equipment, all indicators up to 3 in. in diameter can be used with precision and ease. In use, the desired dial indicator is attached, by means of the suitable adaptor, to the magnetic base holder, and the unit is placed so as to bring the dial contact point into position for making the test.

The design of the unit bottom permits it to be mounted on flat, round, or curved surfaces or even on a shaft or pipe. The universal ball and socket construction plus the adjustability of the adaptors assure absolute precision positioning. And the powerful magnet assures positive rigidity at all times.



Enco Mfg. Co., 4522 W. Fullerton Ave., Chicago 39, Ill.

Thermocouple Gage Gives Six Station Readings

An inexpensive vacuum gage in multistation form for coaters, dehydrators, vacuum furnaces, and other industrial high-vacuum equipment is available with two, three, four, five, or six stations, all reading on a single meter. Range covered is from a few microns to 1 mm Hg. More than half the range of the indicating needle is devoted to the region below 60 microns. The smallest meter division represents 5 microns; 1,000 microns is the highest numerical value indicated.

Known as the Thermocouple Gage, Type TG-09, it operates from 115 v 60 cycle circuits. It will be particularly well suited for checking pump operating conditions because of its expanded scale in the region of diffusion pump forepressures. It can be used for displaying continuous readings of pressure at a distance from the point of measurement. No harm results from operation at full atmospheric pressure.

The working principle of the gage is based on the emf developed by a thermocouple in which the temperature differential depends on heat loss by gas conduction; this, in turn, depends on gas pressure. The sensitive element in the gage tube consists of a thermocouple junction to which heat is supplied at constant rate. A voltage regulator circuit keeps the heating current constant despite line fluctuations. In the presence of organic vapors, zero drift is reduced to a minimum because the low operating temperatures in this gage cause little decomposition.

The gage tube may be mounted vertically and plugged directly into the control cabinet with the cable omitted. For those applications where it is not convenient or even possible to plug the gage into the cabinet directly, a cord up to several hundred feet in length can be used without ill effect. Ten feet of cord is included with each instrument as part of the original equipment as supplied by the factory.

The metal housing of the gage tubes is terminated in a $\frac{1}{8}$ in. IPS nipple. This nipple can be threaded into any suitable coupling and the threads can then be sealed with a high-vacuum type wax to prevent pressure leaks from the atmosphere. Alternatively, it is possible to make this connection with a standard CGB connector, or with a short piece of rubber tubing covering a butt joint between the gage tube and the pipe to the vacuum system.

A new single station thermocouple gage Type TG-08 which operates on 2 flashlight dry cells is also available at this time. Additional information and descriptive literature concerning both gages is available from the manufacturer upon written request.

Distillation Products Ind., Rochester 3, N. Y.

CONTINUED ON PAGE 190

HERCOCEL*E ANSWERS a Call for Ethyl

. . . this time from the Signal Corps for the telephone handsets used in mobile units. It's a call for top performance in plastics whatever the time or place. This durable all-weather plastic serves well under conditions ranging from arctic cold to tropic heat and humidity, in a variety of applications involving severe exposure.

As a result of many such calls, the present supply of Hercocel E available for non-defense needs has been sharply curtailed. But there's still no limit here at Hercules on the design and technical assistance available to you in the long-range development of new uses for this versatile *quality* plastic. We invite your inquiries.

HERCULES POWDER COMPANY *Cellulose Products Department • 904 Market St., Wilmington, Del.*

MOLDABILITY
•
IMPACT STRENGTH
•
DIMENSIONAL STABILITY
•
LIGHTWEIGHT
•
DURABILITY
•

Signal Corps telephone handset molded with Hercocel E (ethyl cellulose molding powder) by Cowan-Hayden Corporation, Providence, Rhode Island, for Connecticut Telephone & Electric Corporation, Meriden, Conn.

***HERCULES** Cellulosic Plastics*

*TRADE-MARK

CP51-6

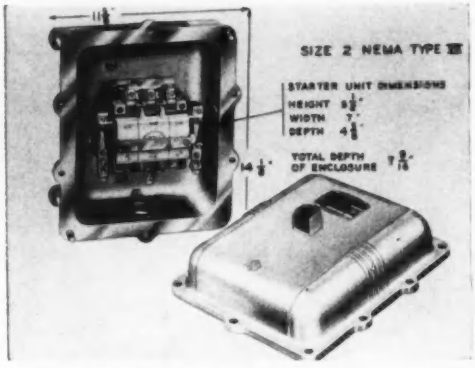
Weatherproof Magnetic Starters Are Light and Small

Featured in a line of weatherproof magnetic starters, is a compact and rugged Feraloy cast housing in combination with a "RA" (Right Angle) type of mechanism.

Another feature is light weight. Described as ⅔ the size and weight of other makes, it is claimed that one man can comfortably carry and install a size 2 starter without a truck or chain hoist.

Explo-Safe and Weatherproof Magnetic Starters have straight-thru wiring and ample working space for easy installations. Terminals are accessible from the front, as are the contacts which are said to be simple to replace. Line and load may be completely separated; circuits immediately identified.

Typical applications are found with manufacturers of chemicals, explosives, fertilizers, soaps, paints, papers, petroleum, pharmaceuticals, plastics, rubber, textiles, and in processing plants such as woodworking or grain milling. Starters are available in sizes 0, 1, 2, 3, and 4.



Arrow-Hart & Hegeman Electric Co., 103 Hawthorn St., Hartford 6, Conn.

Pilot Valve Solenoid Housing Is Explosion-Proof

An explosion-proof solenoid housing for electrically operated pilot controlled valves can be used wherever fire and explosion hazards exists. It is manufactured of cast-aluminum to Underwriters' Laboratory specifications, Class 1, Group *D*, Air Break Type.

Provision is made for standard conduit connection. The cover may be used with ¾ in. to 1¼ in. size Ross pilot operated straight-way, three-way, four-way and four-way five port models for single solenoid operation; this housing may also be used for double solenoid, momentary operation of Ross base mounted pilot controlled valves. Completely effective protection is realized.

Additional information on the various uses and also the effectiveness of the explosion-proof solenoid housing can be obtained without charge from the manufacturer. A list of factory recommended procedures for installation is also available upon written request.

Ross Operating Valve Co., 120 E. Golden Gate, Detroit 3, Mich.

Teflon Extruded Rods Available

Continuously extruded Teflon rods and tubing in diameters of $\frac{1}{16}$ in. are now being commercially produced and offer considerable economy in the machining of parts such as spacers and insulators for high frequency equipment. Teflon tubing from ⅛ in. through 5 in. ID is also being produced on a commercial scale. Larger sizes can be made to special order.

Typical parts made of Teflon rod and tubing include insulators for electronic equipment, valve and pump packing, gaskets, and washers.

The Polymer Corp., Reading, Pa.

Reduction Unit Handles Up to 40 Hp

Rugged, yet compact, a new reduction drive unit will handle drives up to 40 hp. The No. 6 unit features high-capacity, antifriction bearings for long, efficient service; heavy internal-ribbed housing assuring permanent gear and bearing alignment; forged, heat-treated, alloy-steel helical gears providing ample capacity and quiet operation; exclusive oil-seal design and location above oil level to prevent oil leakage; and ample housing area eliminating the possibility of damage by overheating.

American Pulley Co., 4200 Wissahickon Ave., Philadelphia 29, Pa.

CONTINUED ON PAGE 192

for

BORON STEELS

WITH FINE GRAIN SIZE

USE *Grainal* ALLOYS

Grain growth inhibitors in metallurgically determined amounts are included . . . in addition to boron . . . among the elements composing Grainal alloys.

Because of the beneficial influence of these additional elements, boron steels made with Grainal alloys maintain finer grain size at higher temperatures than is the case of boron steels made without inhibitors.

VANADIUM CORPORATION OF AMERICA

420 LEXINGTON AVENUE, NEW YORK 17, N. Y. • DETROIT • CHICAGO • CLEVELAND • PITTSBURGH

MAKERS OF ALLOYS

VANCORAM

CHEMICALS AND METALS

R-F Generator Heats Materials Dielectrically

A 5 kw radio-frequency generator for dielectrically heating a wide range of nonmetallic materials in the textile, rubber, wood, food, and other industries, is readily adaptable to batch or continuous production methods, delivering rated power at a 100 percent duty cycle, measured by approved NEMA standards.

This unit can be supplied in either of two styles: with 6.8/13.6 megacycle dual-frequency oscillator for low- and medium-power-density requirements—such as large area panels to be heated for glueing, or with a 27.1 megacycle oscillator for high-power-density loads—such as plastic preforms.

Equipment operating controls are held to a minimum. with all control adjustments made from the front panel. This, plus a full complement of protective devices, puts operation of this equipment on a semi-skilled basis.

The enclosure is designed to minimize radio-frequency radiation, and the complete generator is certified to comply with FCC regulations.

Westinghouse Electric Corp., Pittsburgh 30, Pa.

Fractional Hp Manual Starter Controls 1 Hp Motors

A fractional horsepower manual starter designed to control and protect single phase a-c and d-c motors of 1 hp and less is available in single- and double-pole-models. The rugged double-break contact mechanism has quick make and break action and contact tips are of fine silver. The starter incorporates dependable, trip-free overload protection which gives a definite trip indication. Interchangeable overload relay units are accessible from the front. Line and load terminals are arranged for straight-through wiring.

Three types of enclosures are available as well as the Class 2510 Type *A* open type starter: general purpose (NEMA I), water- and dust-tight (NEMA IV and V), and explosion-resistant (NEMA VII and IX). The general purpose enclosure is die-cast aluminum and can be supplied with a pilot light for 115 and 230 volt operation without increasing the over-all dimensions. The water- and dust-tight enclosures (NEMA IV and V) are made of cast aluminum and can also be supplied with a pilot light. Four bolts are used on this enclosure to hold the cover in place and a special purpose gasket completes the seal.

The explosion-resistant type enclosures (NEMA VII and IX) are made of cast iron. Four lugs are used to retain the cover and the surfaces of the box and cover are accurately machined to obtain the desired protection.

All types of enclosures are designed to provide generous space for wiring. A standard switch box and flush plate can be used with the open type switch unit.

The starter has been designed to offer accessibility, effectiveness and dependability. More detailed information on either the design or the performance of these manual starters can be obtained without obligation from the manufacturer upon request.

General Purpose (NEMA 1) Manual Starter, shown above, has a die-cast aluminum enclosure of the closed type, and can be used with a standard type switch box.

Square D Co., 4041 N. Richards St., Milwaukee 12, Wis.

CONTINUED ON PAGE 194

Customer Reports:

ONLY 250 LBS. REJECTED OUT OF 2,000,000 WITH ASARCO CONTINUOUS CAST BRONZES!

A prominent manufacturer of railroad equipment reports: Only 250 lbs. of Asarco Continuous Cast bronze rejected out of a 2,000,000 lb. experience . . . better properties than other bronzes . . . scrap losses practically eliminated.

There are virtually no rejects when you use Continuous Cast bronzes. The unique Asarco casting process gives you bronze rods, tubes and shapes with fatigue and impact characteristics up to 100% better than those of sand cast bronzes . . . with better tensile strengths, yield strengths and hardnesses . . . with no porosity, no hard or soft spots. Asarco Continuous Cast bronzes are ideal for use on automatic screw machines.

You can get Continuous Cast bronzes made to order in a wide variety of alloys . . . in standard lengths of 12′ . . . lengths 5′ to 12′ on request . . . lengths 12′ to 20′ on special arrangement.

216 sizes of the standard Asarcon 773 bronze (SAE 660) are stocked in 105″ lengths for convenience at warehouses in principal cities across the country. Distributors will cut the warehouse stock to suit your specific requirement . . . *long or short.*

For more data see your Asarco distributor, or send the coupon for a 12-page color catalog that contains complete technical data.

ASARCO CONTINUOUS-CAST RODS · TUBES · SHAPES ®

West Coast Sales Agent:
KINGWELL BROS. LTD., 444 Natoma Street, San Francisco, Calif.

American Smelting and Refining Company
OFFICES: Perth Amboy Plant, Barber, New Jersey
Whiting, Indiana

American Smelting and Refining Company
Perth Amboy Plant, Barber, New Jersey

Please send me a free copy of the new 12-page catalog "ASARCO Continuous-Cast Copper Alloys."

Name..... Title.....

Company.....

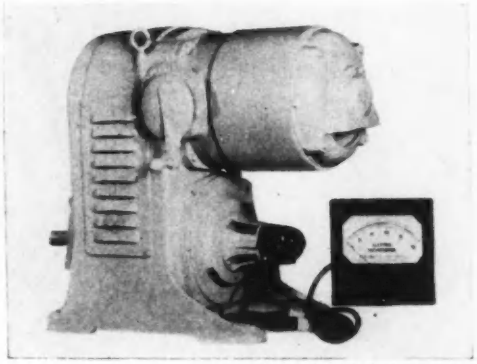
Address.....

City..... Zone..... State.....

Electric Tachometer Coupled to Motor

For motor applications that require continuous and accurate speed indication, an electric tachometer arrangement is available with Model R-1 tachometer and generator in ratings from ¼ to 50 hp and speeds from 20 to 10,000 rpm.

The permanently lubricated, ball-bearing type generator is coupled to the variable speed drive and requires no other source of power. The tachometer indicator is entirely enclosed to prevent entrance of dust and other foreign particles, and can be mounted at distances up to 300 ft from the drive without affecting accuracy. The indicator dial shows operating speed as a percent of the max output speed. For example, if the max speed is 1,000 rpm and the dial indicates 60 percent, the drive speed would be 60 percent of 1,000 or 600 rpm. By the use of a percentage indicator, the rate of production of a given machine is instantly available. Other forms of dial indication are also available upon order. Supplied with each unit is 10 ft of two-conductor cable, making possible the mounting of the tachometer in the most advantageous or the most convenient location within a 10 ft. radius.



U. S. Electrical Motors, Inc., 200 E. Slauson Ave., Los Angeles 54, Calif.

Forged Steel Gage Valve Has Male Inlet

A new forged steel gage valve in half inch sizes is now available with male inlet and female outlet.

The new gage valve requires no nipples, as for example, when hooking up pressure gages to pressure tubing or casing, because the male inlet basically serves the same purpose as a nipple. The male inlet is an integral part of the forged steel valve body offering greater strength and soundness. Its wall thickness is extra heavy for high pressures and provides greater protection against breaking off or rupturing.

Over-all compactness makes the valve desirable for the cramped areas in instrument piping or for installation on manufacturer's equipment. A safety taper threaded joint between the body and bonnet prevents the bonnet from backing out of the valve due to vibration.

Features include a long taper, semi-needle, 13 percent chromium stainless steel stem disk with fine pitch thread for close regulation of flow; back-seating shoulder for repacking under pressure; extra broad seat joint for tight closure; and bonnet and packing nut plated to reduce possible galling and corrosion. Ratings are 4,000 lb at 150 F or 600 lb at 750 F for this new gage valve.

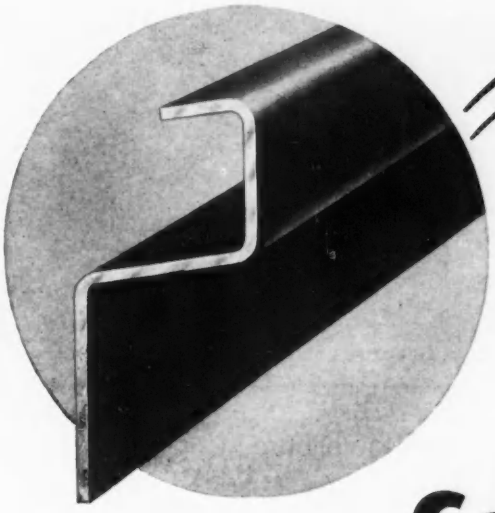
Edward Valves, Inc., East Chicago, Ill.

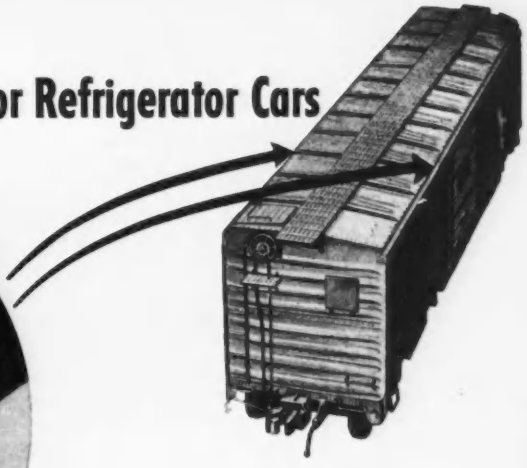
AIR-FUEL RATIO CONTROLLER adjusts air flow to fuel flow changes rapidly, without cycling. Applicable to oil or gas firing, or to dual-fuel furnaces, it meters both fuel and air flow for maximum accuracy of control. Available for use where ratio control alone is desired, this instrument operates an electric or a pneumatic control valve. Major sub-assemblies are standardized, readily replaceable. Leeds & Northrup Co., 4934 Stanton Ave., Philadelphia 44, Pa.

HIGH TEMPERATURE PAINT, capable of withstanding temperatures up to 1,900 F, can be applied to all types of wood or metal surfaces by conventional methods. It forms a bright finish that is resistant to moisture, corrosion by mild alkalies and acids and oxidation. Research and Development Lab., Fire-Gard, Inc., Baltimore 2, Md.

CONTINUED ON PAGE 196

Side-Plate Section for Box or Refrigerator Cars





...made by Cold-Rolling

This husky steel section, made on a cold-roll forming machine, is a side-plate section for use in railway cars. Its big advantage is that the car roof can be riveted to the section from outside the car. We make this cold-formed shape from ¼-in. plate steel, and supply it to the car builder in full car lengths.

Side-plate sections are but one of a long line of interesting, sometimes unusual applications of Bethlehem Cold-Formed Shapes. To name a few, we make such diversified items as furnace bands, roof purlins, channels for telephone equipment, shapes for material-handling racks, frames for automobile trailers, and hatch covers for sea-going vessels. There are many more. And the list is growing all the time, for alert manufacturers are continually thinking up new, practical uses for these versatile shapes.

Just what are Bethlehem Cold-Formed Shapes? They are regular or irregular shapes which are formed cold from sheet, strip or plate steel. They vary in size, and can be any of the following:

1. Special section angles, channels or zees
2. Angles and zees combined
3. Channels and zees combined
4. Round or rectangular open-jointed tubes
5. Shapes with 180 deg bends
6. Shapes with combinations of bends
7. Shapes with varying angles

Bethlehem Cold-Formed Shapes are uniform in thickness, and relatively free from scale. They have an excellent strength-to-weight ratio. They come in all gages from 5 to 24, inclusive. In addition to cold-roll forming machines, we also have facilities for turning out these economical shapes on presses and brakes.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

★ BETHLEHEM STEEL ★

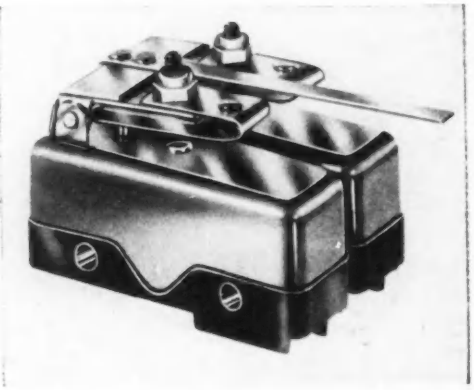
Ganged Switches Are Individually Adjustable

This new ganged-switch asssembly provides for operation of two snap-acting single pole-double throw switches by a single actuating mechanism and for precise, individual setting of the operating point of each unit in the assembly. This construction permits two, three, or four switches to be installed in production and precisely set for simultaneous operation or for operation in special sequences.

The assembly is made up to two standard switches having common bushings through the mounting holes so that the entire assembly can be mounted by two No. 6 screws. A rigid bar joins the plates of the individual switches so that they all work together. The operating point for each switch is adjustable by a set screw that moves a *U*-spring toward or away from the operating pin. The *U*-spring also absorbs over-travel of the actuator arm. The set screw is held by an elastic stop nut.

The actuator bar, *U*-springs, and hinge members are of stainless stel, and Allen set screws are corrosion resistant.

Unimax Switch Div., The W. L. Maxson Corp., New York, N. Y.

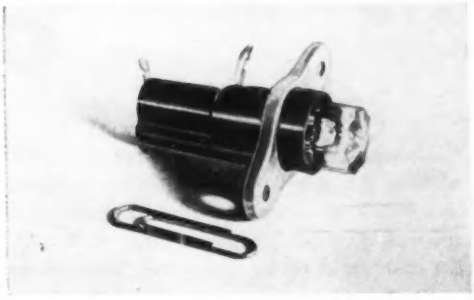


Miniature Fuseholder Spots Blown Fuse

A miniaturized indicating fuseholder saves valuable time by instantly spotting fuse that has blown. The unique design has a neon bulb and double contacts molded as an integral part of the crystal-clear lens. The neon bulb glows when fuse blows and can be seen from any angle, giving an immediate indication of trouble.

This new fuseholder is a compact unit that takes little mounting space on or behind the panel (requires mounting centers and clearance behind the panel of only $1\frac{3}{8}$ in.). Ideally suited to mass production assembly techniques (the rugged steel mounting plate rivets, eyelets or screws to panel with standard production tools) it has solder tabs which facilitate wiring and assembly.

Alden Products Co., 117 N. Main St., Brockton 64, Mass.



Black Oxide Process Operates at Low Temperatures

A new black oxide process for iron and steel has four big advantages: (1) It is a one bath-one salt process and operates at a lower temperature of 290 F. Its requirements of $6\frac{1}{2}$ lb of salt per gallon of blackening solution are said to result in a lower cost for the initial blackening solution and a lower cost for the replenishment of the solution drag-out. Because of the lower operating temperature and the low concentration of salt per gallon, the solution is highly fluid, and this results in a minimum of loss from dragout of solution on the work.

(2) The black oxide finish has high corrosion resistance because the blackening solution has specific ratio of FeO to Fe_2O_3 to form a type of black iron oxide (Fe_3O_4) which will effectively absorb large amounts of the final oil, wax, etc., used as the final dip.

(3) The salt cuts down the blackening time cycle and will also blacken heat-treated or hardened work easily. (4) It is also self-rectifying and will rectify build-up of colloidal red iron oxide in the bath and other contaminants, which might inadvertently be introduced into the solution. Because of this self-rectifying characteristic, steel parts with brazed areas can also be processed through the solution without any difficulties. This rectification is accomplished with the use of non-poisonous chemicals.

Literature describing further details of this process, called Black Magic (Type A) is available from the manufacturer without obligation upon receipt of a written request.

Mitchell-Bradford Chemical Co., 2446 Main St., Stratford, Conn.

CONTINUED ON PAGE 198

We Mobilize for Freedom

CONTROLS . . . A Two-Edged Sword

It may seem dangerously premature to talk about getting rid of emergency government controls while all-out war is still an imminent possibility.

But success in this strange struggle for our freedom into which the Russian Communists have plunged us requires that we:

1. Maintain a whole battery of controls designed to speed defense production and curb inflation, and at the same time

2. Work to end the controls at the earliest possible moment.

Here is the reason why this editorial—fourth in a special series on mobilization for defense—is devoted to the need for a speedy release from controls.

If the Russian Communists can force us to maintain indefinitely the present system of government controls, they will have won a tremendous victory. They will have saddled us with a system of collectivism which, over a period of years, would be fairly certain death to freedom of business enterprise.

Make no mistake about it. This is not an argument against emergency controls. We need controls now to break a right of way for our mobilization program through the business boom. Indeed, the third editorial in this special series was titled "Why Controls Are Necessary." It stressed both the need for controls and the need for positive cooperation to make them work.

Controls Can Undermine Our Economy

But these controls surely chisel at the foundation of our normal economic system. So long as we have them, many if not most key business decisions will be made in Washington bureaus rather than in the free market place. For example, the *National Production Authority* administers a *Controlled* Materials Plan (italics ours) which directs the flow of basic metals, and decides who can use them for what purposes.

Happily, the people who operate these controls are not using the methods of a secret police state.

Even more happily, most of the leaders who have been drafted to manage the controls are not in love with their jobs. They are doing their best in the thankless task of making controls work. They recognize the danger of chronic controls.

But the fact remains that our economy is

operating under arrangements which carry it a long way toward the pattern of centralized control the Russians would inflict on the world.

The Wilson Plan

A plan for getting rid of these controls has already been developed. It was put together by our Director of Mobilization, Charles E. Wilson—while he was working day and night to set up the necessary emergency controls.

The Wilson Plan—if we escape all-out war—will strengthen our defenses and our economy. By 1953, it calls for:

1. Providing the weapons to equip an armed force of 3½ to 4 million, together with a supply of weapons for our allies.

2. Building a stockpile of weapons which, with current production, would be sufficient to carry on an all-out war for a year.

3. Building the manufacturing capacity by which we could rapidly expand our production of weapons if all-out war should come.

4. Increasing the productive capacity of industry enough to resume the expansion of our civilian economy.

With these jobs done our economy would be big enough and strong enough to meet both civilian and military requirements. And the government controls needed for mobilization could be speedily dropped.

Call for Sacrifice

The Wilson Plan requires a major effort—it means spending more than $50 billion a year for mobilization. That is almost 20 percent of our total production. And this cannot be done without sacrifice. For a time, particularly in the next year, living standards will drop.

But the sacrifice required is amazingly small. At the peak of the defense effort, civilians will still have available to meet their needs about as much as they did in any year before 1948.

To make the Wilson Plan succeed we must curb inflation. A second year of inflation such as that which we have had since the Korean war started would multiply disastrously the costs of our defense program. One key part of a successful program to curb inflationary pressure, which soon will be building up again, is a pay-as-we-go tax program. The second editorial in this series urged that we do our utmost to pay as we go.

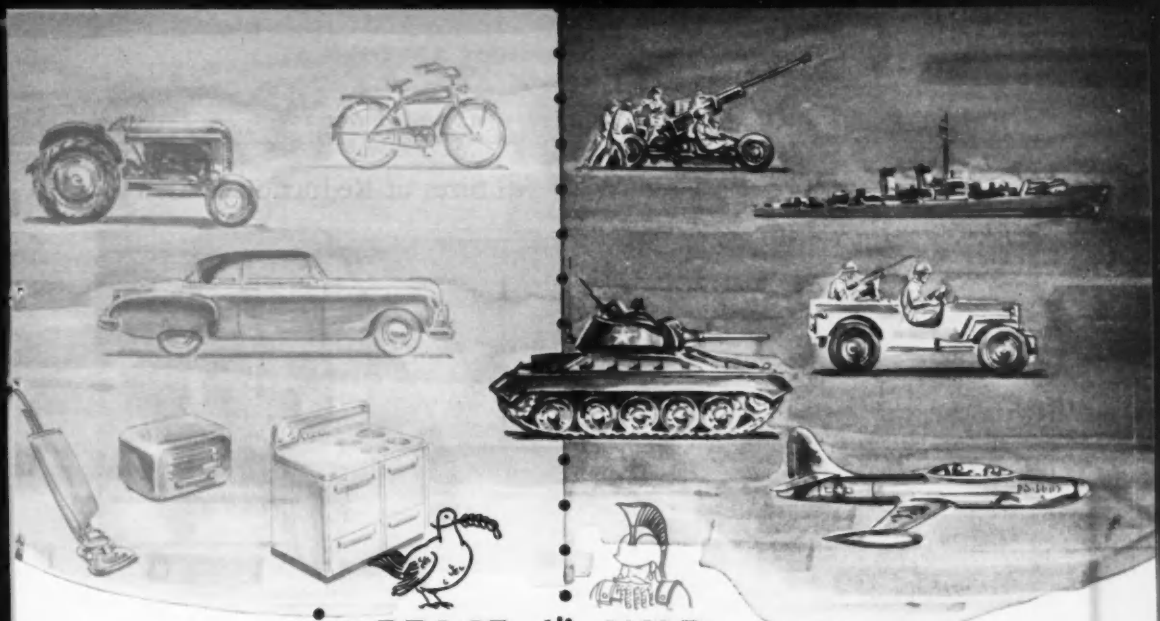
We Cannot Out-Control the Communists

But, above all, to make the Wilson Plan work we must keep our sights set on the crucial importance of increased production. Our problem is to increase our capacity to produce so that we can carry both a major military program and an expanding civilian economy for as many years—General Bradley thinks it might be fifteen or twenty—as the menace of Russian Communist aggression persists.

If we do not produce enough to do this double job, we shall be confronted with the prospect of having to live indefinitely under government controls of the sort that have been set up since the start of the Korean war. That would be delightful to the Russian Communists. It would go far toward making over our economy on the Moscow model.

Even if we wanted to, we never could hope to out-control the Russians. They are miles ahead of us in that line. But we can out-produce them, by a tremendous margin. By doing that we shall travel the surest road to victory.

McGraw-Hill Publishing Company, Inc.



in PEACE or WAR

approximately 2½% of the steel produced is used to fasten the rest together

• You've heard the expression "tail wags dog". Well, that's pretty much the relationship between steel fasteners and the bulk of the steel utilized in fabricating products. Without fasteners most of the steel produced would be useless.

Fasteners are truly the *key* to production.

• Lamson & Sessions — as one of the country's oldest and largest "full line" fastener manufacturers — have long held a key position in supplying the production lines of industry with fasteners of many types. Today, with the rearmament program gaining momentum, Lamson again stands ready to help solve *your* fastener problems.

You are invited to call on us — anytime.

The home of "quality controlled" fasteners

Lamson + Sessions

The LAMSON & SESSIONS Co. • • **General Offices: 1982 West 85th Street • Cleveland 2, Ohio**

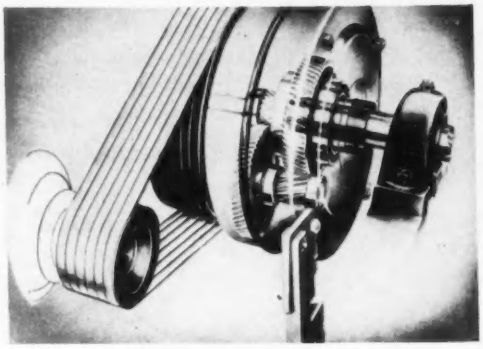
Plants at Cleveland and Kent, Ohio • Birmingham • Chicago

Overload Release Can Be Used With All Sizes of Reduction Drives

A simple mechanical overload release for use with all sizes of American Reduction Drives is used on the reducer end of the torque arm and is so constructed as to engage the housing stud of the unit. The overload release mechanism is preset for maximum torque and works equally well, whether the torque arm is mounted so as to be in tension or compression. It provides instantaneous release of the unit upon any excessive jamming or shock loads, thus protecting both the motor and the machinery against damage.

This release, is easily re-engaged without the use of tools, shear pins, or any other part, and will provide dependable operation throughout the life of the drive.

Additional information on this new safety device is available from the manufacturer upon request.



American Pulley Co., 4200 Wissahickon Ave., Philadelphia 29, Pa.

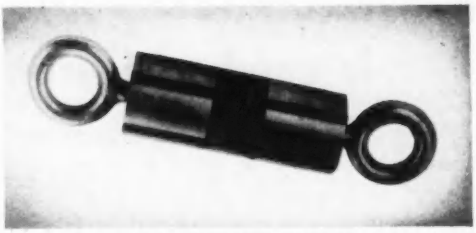
Silicone Rubber—Metal Bond Is Stronger Than Rubber Itself

A bond between silicone rubber and metals or ceramics that is stronger than the rubber itself is possible with a new chemical development designated as G-E 81267 primer.

By using this liquid, silicone rubber can be bonded to almost any surface. Bonds to glass, ceramics, aluminum, steel, tin, and copper are possible, and sheer strength measurements of bonds on steel are approximately 700 psi. A unique feature of the primer is its ability, in most cases, to develop a bond strength greater than the strength of the rubber at any stage of the cure.

The technique of applying and using this primer is quite simple and easily fits into the fabricating techniques now employed with the newer silicone rubber compounds. To mold and bond these silicone rubbers to a surface, it is necessary first to remove all grease and dirt from the surface. The primer, is then applied by dipping and draining, spray, or brushing. The film should then be allowed to air-dry for 20 min. Some surfaces, such as tin, require a short heat treatment to complete the drying. The surface is then rinsed with water and dried.

The primed surface can now be molded under pressure at 125 C against freshened high-strength silicone rubber compound from 10 to 20 min, or 20 to 25 min in 40 psi steam, and may usually be removed from the mold hot.



BABY ELEPHANTS MUST EXERT more than 1,500 lb of pull to break the bond between silicone rubber and two pieces of steel.

The development of the new primer makes possible a wide variety of silicone rubber-to-metal molded products which include shock and engine mounts that resist both high and low temperatures. Also, improved rubber-glass laminated structures are possible, and high-strength silicone rubber in conjunction with the new primer can be used as an adhesive with unusual new properties.

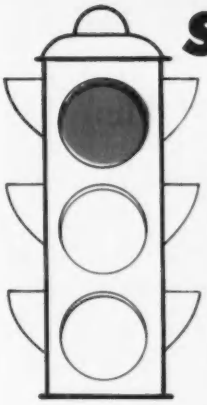
General Electric Co., Pittsfield, Mass.

A PRIMER which contains a type of vehicle new to the paint industry is capable of locking paint film—particularly vinyls—to surfaces having adherent rust and reduces the splitting of top vinyl finishes (notorious for peeling from sharp edges) to nearly zero. Furthermore, the primer shows evidence, upon visual inspection 60 days after application on rusty surfaces, of reducing portions of the rust particles from iron oxide to iron. In fact, the primer works better on rusty surfaces than on clean shiny metal and will not replace standard primers on new or sandblasted steel parts. Carboline Co., 7603 Forsyth Blvd., St. Louis 5, Mo.

NEW POTENTIOMETER can measure altitude for bombing missions within a maximum error of about one-fourth that formerly considered unavoidable. Production must be almost infinitesimally precise. Even variance of one-millionth of an inch in the resistance wire means discarding a potentiometer for exceeding the allowable deviation. The Gamewell Co., Newton, Mass.

SEALING TAPE for carton interliner and outer seams and for covering and protecting labels is resistant to water, rough handling and weather. Minnesota Mining and Mfg. Co., St. Paul, Minn.

—CONTINUED ON PAGE 200



STOP!

DAMAGE TO MACHINERY

WORK SPOILAGE

COSTLY DOWN-TIME

WITH **MAXITORQ**

automatic OVERLOAD *RELEASE* CLUTCH

When an accidental overload occurs on some types of high speed automatic machinery... packaging, wrapping, can and bottle labeling machines, for instance... there's the devil to pay. Glass may fly, cans be dented, wrappers and labels spoiled, machine mechanisms damaged... perhaps an operator injured. And costly down-time bites into profits.

But... there's an answer... the Maxitorq automatic Overload Release Clutch for original equipment in such machines. Where the nature of the overload is either a heavy shock or a suddenly applied load of a magnitude substantially greater than normal driving load, the O-R Clutch instantly releases... stopping the machine, preventing damage to machine and product. When the jammed condition has been cleared the clutch is re-engaged and the machine is again in operation.

Because this clutch *does* have definite limitations it must be properly applied for maximum effect... and Maxitorq engineers will gladly provide practical recommendations. There are six sizes of clutches (¼ to 5 H.P. @ 100 r.p.m.) and Hub, Ring, Flange and Cut-off Coupling Cups for connecting clutch to driven or driving member. Complete details on request.

Send for Bulletin No. PE 7

"MAXITORQ GOES TO WORK", a new booklet featuring 16 Case Histories of interesting installations of Maxitorq Clutches.

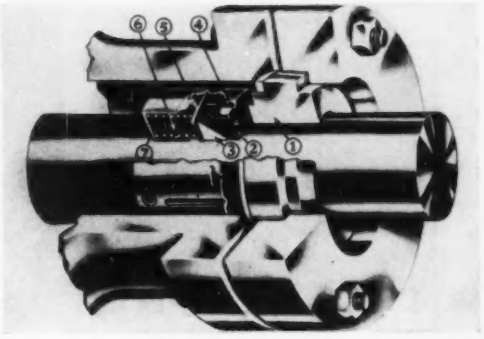
THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER • CONNECTICUT

Mechanical Seal Incorporates Teflon Sealing Member

An improved mechanical seal designated as the Type 9 Mechanical Shaft Seal, which performs effectively under severe temperature and corrosive conditions, incorporates a flexible ring molded from the new plastic, Teflon. The Teflon "wedging-ring" enables the seal to combine chemically inert properties with flexibility and positive sealing action essential to effective mechanical sealing.

Designed for service on various rotating shaft applications, such as centrifugal pumps, turbines, positive displacement pumps and agitators, the seal operates with consistent efficiency on varied corrosive services never previously handled by conventional, flexible-type mechanical seals. It can be employed at temperatures up to 500 F.

Construction of the seal is shown in the cut-away drawing. The set-screwed metal retainer (7) provides a positive drive from shaft to carbon sealing washer (2) through dents (4) which fit into washer notches. An effective seal between the shaft and washer is insured by the precision-machined Teflon wedge ring (3), which is pre-loaded by the action of multiple springs (6). Spring pressure is uniformly distributed by a metal disk (5). The lapped raised face of the rotating sealing washer (2) mates against the highly lapped face of the stationary seat (1) to provide a positive leakproof seal with minimum running friction between the vertical faces. Spring pressure keeps the faces in constant contact providing automatic adjustment in order to compensate for wear and shaft end play.



Crane Packing Co., 1800 Cuyler Ave., Chicago 13, Ill.

Servo Amplifier Has Wide Range of Adjustment

A 60 cycle servo amplifier designed to drive a motor with 5 watt output features controls on the gain, carrier phase shift, and damping, with the adjustments independent one from the other. With this range of adjustment, the 410-B can be used in all servo loops in this power class, for the performance can be optimized in each problem.

Specifications are as follows: max gain: 1,000; phase variable from +20 to —140 deg; internal pickup below 3 mv rms; moderate power supply requirements. Companion power supplies and modulators are available, and the 410-B itself can be obtained packaged to suit some particular spatial problem.

This unit is directed especially to the system engineer faced with the problem of building a working servo loop quickly. Its range of adjustment makes it a stock item with universal application. Its use is claimed to allow bypassing the time-consuming circuit development otherwise necessary in a servo program.

Industrial Control Co., 1462 Undercliff Ave., New York 52, N. Y.

A CAST IRON, CLOSED-END PROTECTING TUBE for molten aluminum applications features a service life several times that of former models. The tube is described as being of dense cast iron having a smooth outer skin. The tube is $1\frac{5}{16}$ in. O.D. by $\frac{3}{4}$ in. I.D. It comes in lengths of 12, 18, 24, 30 and 36 in. First shipments are scheduled for about Sept. 15. A two-conductor 24 gage copper constantan thermocouple wire with moisture-proof insulation has been developed for refrigeration applications. Temperature range is minus 20 to plus 225 F. Another thermocouple, portable immersion, removable-tip type, has been developed for measuring temperatures of molten steel. Readings in 15 to 25 sec of immersion in molten steel having a carbon content of 2.5 percent or more, through a range from 2,400 to 2,900 F are accurate within 15 degrees. Minneapolis-Honeywell Regulator Co., Brown Instruments Div., Wayne and Windrim Aves., Philadelphia 44, Pa.

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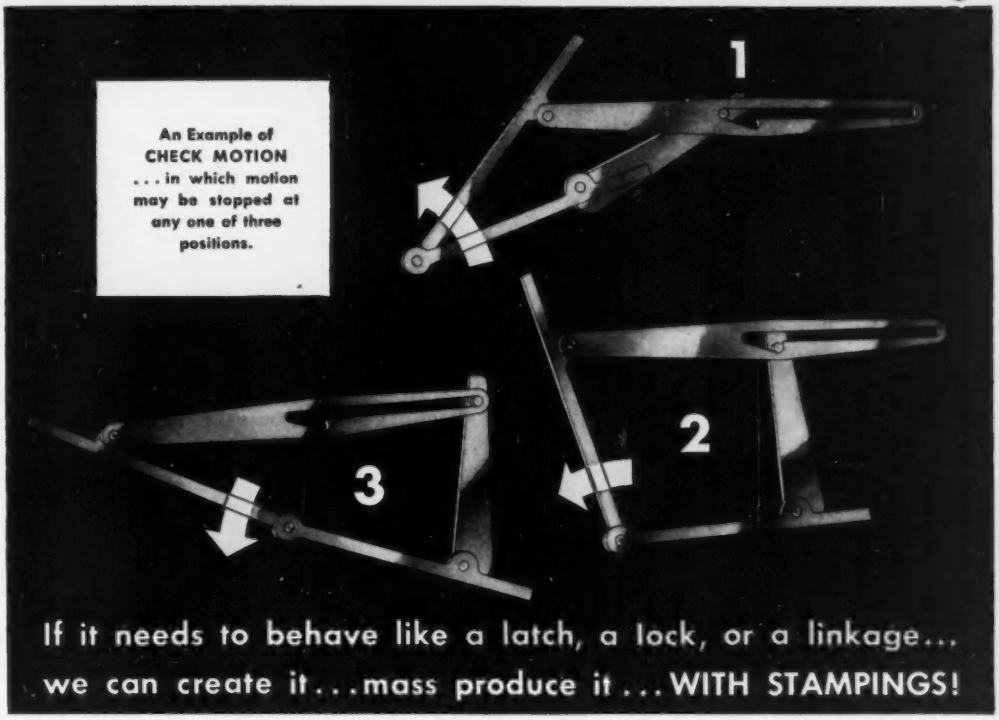


If it needs to behave like a latch, a lock, or a linkage...
we can create it...mass produce it...WITH STAMPINGS!

Perhaps your product requires a carefully-engineered motion device to enhance its safety...performance... salability.

We produce such devices to very close tolerances with STAMPINGS... and by modern mass production and assembly techniques, we can keep the cost unusually low.

That's why you'll find Standard locks and latches on many of the new model cars. It's a reason why you may want to investigate our facilities further. Why not send for our new booklet "We Make Motions"—which explains in more detail how we can help solve your "motions" problem.

THE REID DIVISION OF *The Standard Products Co.*

THE MARK OF A SUPERIOR PRODUCT

DEPT. B, GENERAL OFFICES: 2130 WEST 110 STREET • CLEVELAND 2, OHIO

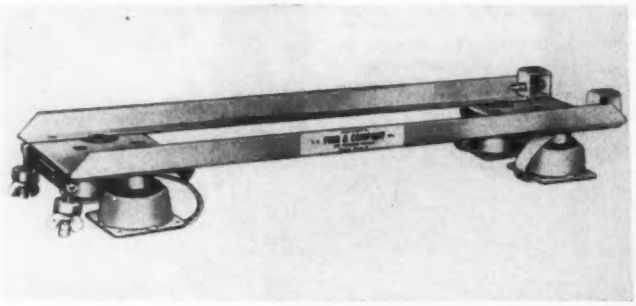
WE MAKE MOTIONS

Finnflex Mounting Bases Protect Airborne Equipment

Designed to protect air-borne equipment such as aircraft radios, radar, loran, and similar electronic apparatus, Finnflex mounting bases are suitable for military and commercial installations.

The mounting base is carried by four metallic spring-type isolators, which provide protection by maintaining their high vibration-isolating efficiency from —80 to +250 F. "Selective-action" friction dampening prevents excessive movement at resonant frequencies.

The load range of the base is 6 to 80 lb. It is designed to meet dimensional and metal requirements of Joint Army-Navy C-172A specifications, and it exceeds Army-Navy E-19 drop test requirements.



The manufacturer provides laboratory facilities to test these mounting bases with mockups, or actual equipment under controlled conditions.

Further details on specifications and performance of these mounting bases can be obtained from the manufacturer upon written request without cost or obligation.

T. R. Finn & Co., Inc., 333 Jackson Ave., Bronx 54, N. Y.

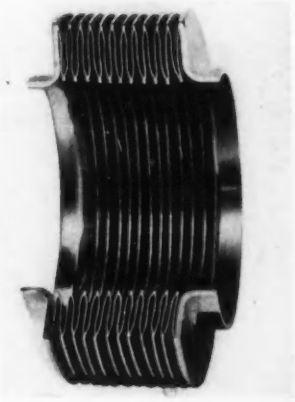
Expansion-Type Bellows Absorb HF Vibration

Expansion-type bellows for the absorption of high frequency vibration and lineal expansion in many types of equipment are constructed of convoluted metal diaphragms welded into complete units. They have been found especially suitable for applications involving constant high pressures, corrosive liquids and gases, and extreme temperatures in sealed piping systems. Severe performance tests have been conducted on these units over the past months to insure their suitability.

Available in sizes from 1 to 5 in. ID in various lengths they are manufactured in plain and stainless steels, brass, bronze, Monel and Inconel according to individual heat, pressure and corrosion requirements, and may be supplied with or without sleeve liners. Height of the convolutions themselves varies according to the degree of flexibility required within a specified length, and wall thicknesses may be increased dependent on pressure requirements.

In addition to the bellows themselves, assemblies complete with any types of standard or special fittings are available.

Further information concerning the numerous specific industrial and laboratory applications of these expansion type bellows can be obtained upon request. Also available are construction and design details, and more detailed information on the performance characteristics of all sizes.



Titeflex, Inc., 500 Frelinghuysen Ave., Newark, N. J.

TUBING for use as hydraulic cylinders, shock absorbers and other applications where pressure is to be converted into mechanical movement has better mechanical properties than hot-rolled or cold-drawn standard varieties. Surfaces of the tubing are so smooth that they need no machining for use with leather or other soft packing such as is used for cup pistons. For use with metal piston rings, the tubing requires no boring but only a light honing operation. Sizes: 1½-6 in. ID. Tube Reducing Corp., Wallington, N. J.

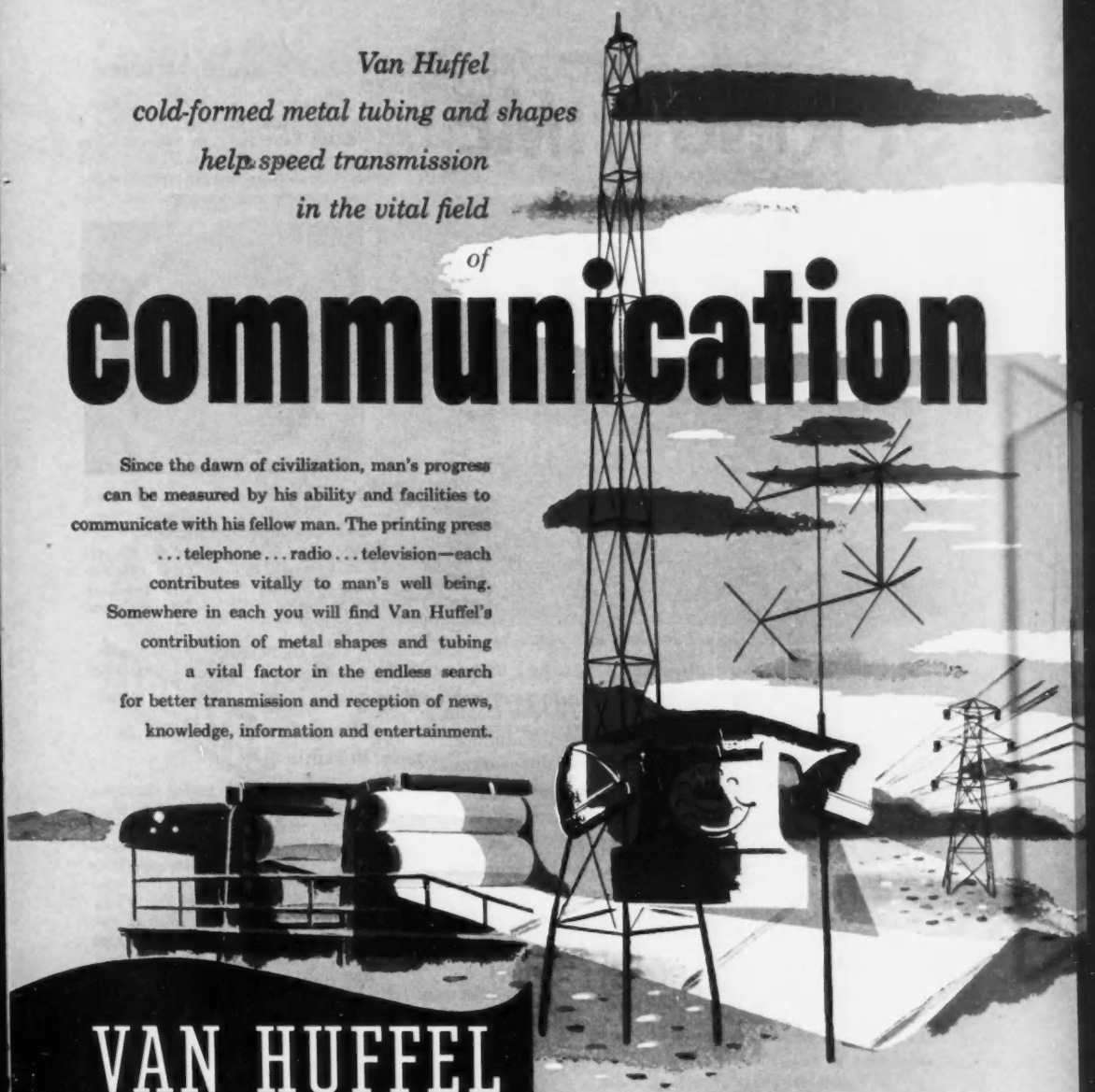
RECOMMENDED AS A REPLACEMENT FOR cadmium or zinc in many rust-proofing applications, superior corrosion resistance is credited to Perm-Cote, a new phosphate coating material. When immersed, iron and steel surfaces are chemically converted into a dark gray, uniform, dense, non-metallic phosphate coating. After rinsing, the highly absorbent coating is impregnated with a rust-proofing oil known as Perm-Oil, giving the products a permanent corrosion-proof layer that is dry to the touch. Standard salt spray tests indicate a resistance well in excess of the 36 hours required by Army specifications. Detrex Corp., Box 501, Detroit 32, Mich.

CONTINUED ON PAGE 204

Van Huffel
cold-formed metal tubing and shapes
help speed transmission
in the vital field
of

communication

Since the dawn of civilization, man's progress can be measured by his ability and facilities to communicate with his fellow man. The printing press ... telephone ... radio ... television—each contributes vitally to man's well being. Somewhere in each you will find Van Huffel's contribution of metal shapes and tubing a vital factor in the endless search for better transmission and reception of news, knowledge, information and entertainment.



VAN HUFFEL

TUBE CORPORATION • WARREN, OHIO

WELDED, LOCK SEAM, OPEN SEAM, BUTTED TUBING, SHAPES AND MOULDINGS

It's always SPRING TIME at NO. 2 JOHN ST.

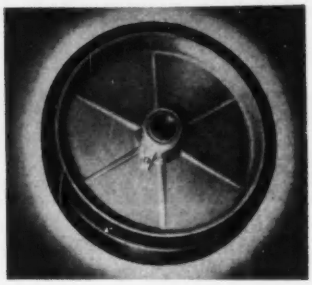
In fact, we at American-Fort Pitt Spring have been making coil springs—all kinds, hot or cold wound—spring, summer, fall and winter, for more than sixty years. Over the years our engineers have worked on almost every conceivable type of spring problem. In many instances their recommendations have helped cut production costs and improve product performance. The springs we furnish are delivered precisely as specified and in conformity with highest standards. When you need springs, the No. 1 place to think of is No. 2 John Street.

AMERICAN-FORT PITT SPRING DIVISION
H. K. Porter Company, Inc.
No. 2 John Street, McKees Rocks, Pa. (Pittsburgh District)

AMERICAN-FORT PITT SPRINGS

Sealed Hub Wheel Excludes Foreign Matter

Of cast aluminum with a solid rubber tread, this industrial wheel has a sealed hub structure incorporating roller bearings. Because the wheel excludes foreign matter responsible for bearing and axle wear and deterioration, it is suitable for foundries, metal and woodworking shops, mills, warehouses, meat packing and other industrial plants. A convenient fitting permits periodic lubrication of bearings and axle without tie-up of handling equipment. The range of sizes runs from 6 in. to 20 in. diameter.



Aerol Co., Inc., 2820 Ontario St., Burbank, Calif.

"Breakdown" Machine Is Portable

A "breakdown" testing machine, designed primarily as a battery tester but adaptable for other shaking and "vibrate to destruction" test operations is used to determine operating characteristics, wear life and suitability of design and materials. Vibrations are produced by rotating two pairs of unbalanced flywheels at high speed, usually 1,000 to 2,000 rpm. Amplitude is adjustable.

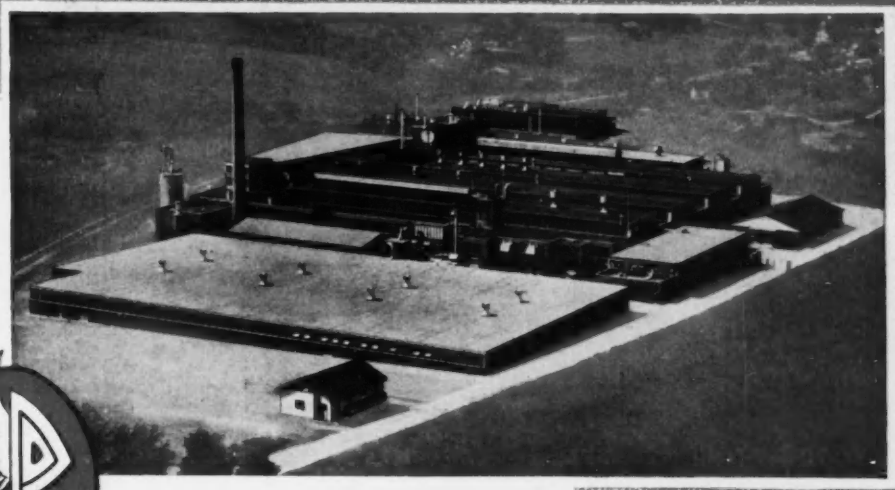
The structural steel chassis is 20 by 24 in. and 32 in. high. Two of the ball bearing wheels are casters for easy portability. The steel top to which the vibrating mechanism is bolted, is mounted on large coil springs. A 1 hp motor is mounted on a hinged plate in the lower part of the frame. A V-belt drive is used.

Deister Machine Co., Fort Wayne, Ind.

Glass-Walled Filters Permits Observation

Stainless steel filtering elements in a pyrex glass container permit full

Are You Seeking a Supplier of ALUMINUM CASTINGS?



PERMITE

Here at Aluminum Industries, Inc., are proven facilities you can count on for supplying aluminum alloy castings of uniformly high quality, in any sizes and in any quantities you need. Just check and compare:

- One of the largest aluminum foundries in the United States for the production of Permanent Mold, Semi-Permanent Mold and Sand Castings.
- Ample capacity for immediate scheduling of your requirements.
- Well-equipped department for machining and finishing aluminum castings.
- Tool room, equipped with the latest type machine tools.
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- Pattern shop for pattern repair and maintenance.
- Engineering Department for application of the best engineering principles, all the way from the design stage to the finished casting.
- Ample warehousing facilities, favorably located for shipping.
- Secondary aluminum plant for the refining of scrap metals.
- Foundry personnel with the skill and "know-how" developed in over 30 years of experience in working with aluminum and its alloys.

Send for new bulletin telling how and why you can depend upon Aluminum Industries, Inc., for the aluminum castings you need in your production. Ask for Bulletin No. 20-A. Recommendations and estimates given without obligation.

ALUMINUM INDUSTRIES, INC.

CINCINNATI 25, OHIO

ALUMINUM PERMANENT MOLD, SAND and DIE CASTINGS...HARDENED, GROUND and FORGED STEEL PARTS

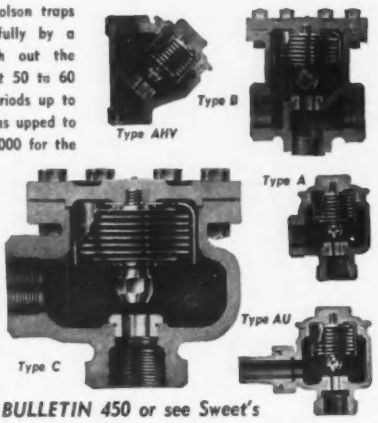
Large Processor Achieves

MORE UNIFORM HEATING CYCLES

with Nicholson Steam Traps

The positive action of Nicholson traps was recently used successfully by a chemical maker to smooth out the heating cycles of cookers at 50 to 60 minutes, against previous periods up to 105 minutes. Steam flow was upped to 3000 lbs. an hour against 2000 for the previous mechanical type.

5 TYPES FOR EVERY APPLICATION, process, heat, power. Sizes ¼" to 2"; pressure to 225 lbs. To learn why an increasing number of leading plants are standardizing on Nicholson thermostatic traps . . .



Send for BULLETIN 450 or see Sweet's

W. H. NICHOLSON & CO., 200 Oregon St., Wilkes-Barre, Pa.

POWER ADVANTAGE in the Top Bracket Power Range . . . V-Type 4-Cylinder WISCONSIN *Air-Cooled* ENGINES, 15 to 30 hp.

These 4-cylinder, V-type Wisconsin Engines meet every heavy-duty power requirement. V-type design assures not only the smoothest power delivery but also represents substantial reductions in engine weight as well as extreme compactness . . . at no sacrifice of rugged construction.

CONDENSED SPECIFICATIONS

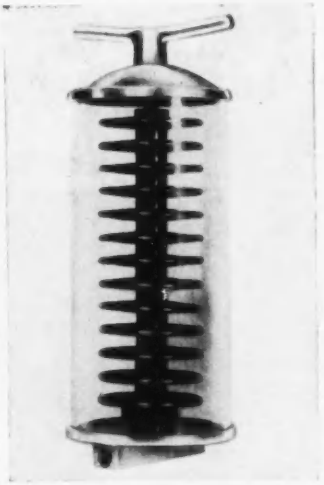
MODELS		VE4	VF4	VP4D
Bore	inches	3	3¼	3½
Stroke	inches	3¼	3¼	4
Displ. cubic inches		91.9	107.7	154
H.P. and R.P.M. range		15 at	17.5 at	26.8 at
		1600	1600	1600
		21.5 at	25 at	31 at
		2400	2400	2200
Net weight in lbs., Standard Engine		295	295	410

Our engineering department will gladly cooperate with you in adapting Wisconsin Engines to your requirements. Write for detailed data and the name of the nearest Wisconsin distributor.

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

MILWAUKEE 46 WISCONSIN



observation of the action of the filter. The filter septum is fabricated from porous stainless steel sheet having a percentage of voids of 50 percent, with pore openings of closely controlled size ranging from 5 microns (0.0002 in.) at the fine end to 165 microns (0.0065 in.) at the coarse end. As much as 8 sq ft of filter area are contained in a unit of 4½ in. dia and 40 in. long.

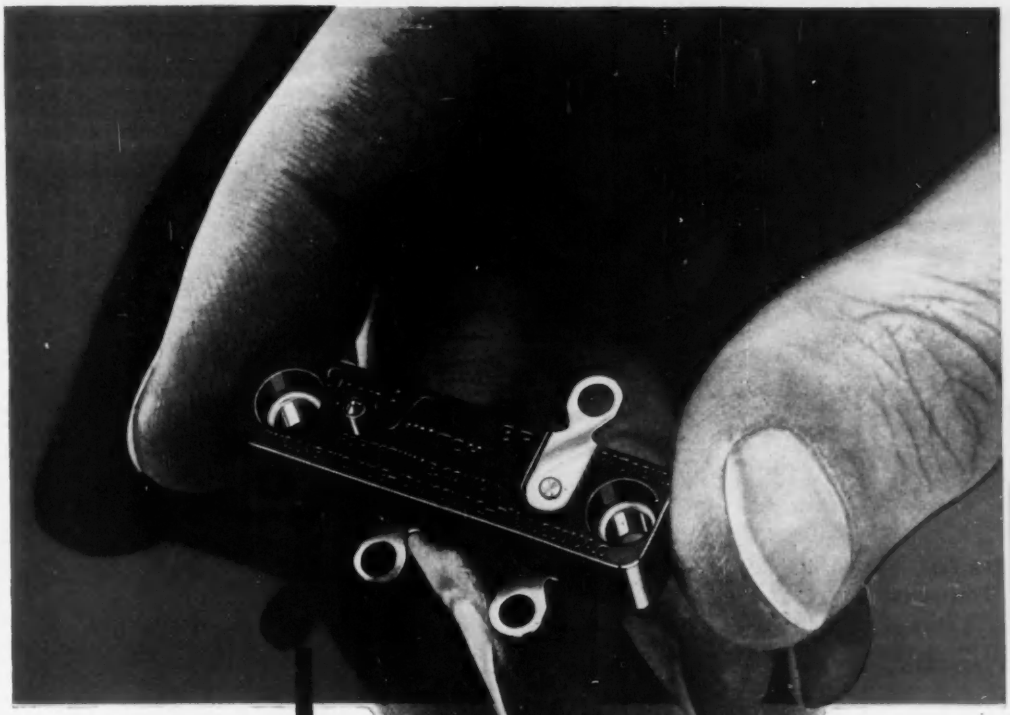
Micro Metallic Corp., 30 Sea Cliff Ave., Glen Cove, N. Y.

Super Rustfree Steels Save Critical Materials

A new series of electro steel alloys have the following features: (1) High yield strength-tensile strength ratio of 75,100:95,300 psi in the hot rolled, fully annealed condition as compared with standard austenitic stainless steels which have a yield strength-tensile strength ratio of about 40,000:80,000 psi.

(2) Fully austenitic, nonmagnetic structure even after severe cold working. For instance, cold finished wire of 0.004 in. diameter and of 300,000 psi tensile strength is dead austenitic, nonmagnetic. (3) Moderate hardness of 82 RB in the annealed condition. (4) High ductility. The alloy has an elongation of 49 percent and a reduction in area of 64.5 percent in the fully annealed condition. (5) High tensile strength at elevated temperatures. All tensile values are higher than those of Stainless 25:12, 18:8 Mo, 18:10 Ti and 18:10 Cb.

(6) Improved corrosion resistance especially against different concentra-



The only miniature snap switch

. . . where size and high rating come to terms with cost

In no other small snap switch can you find the same ideal combination of important qualities. New design principles, found only in TYNISWITCH, permit high load switching in small spaces . . . and at minimum cost. These outstanding advantages are a pleasant surprise to designers heretofore compelled to use switches much larger or more expensive.

You have your choice of a variety of standard stock models. Or TYNISWITCH engineers will develop new models for particular applications. This specialized service offers an economical solution to your most difficult switching problems. TYNISWITCH dependability has been firmly established by thorough tests.

Take advantage of these new benefits. They're your assurance of the best switch value for your money. Write for complete details. TYNISWITCH Division, The Sessions Clock Company, 101 East Main Street, Forestville, Connecticut.

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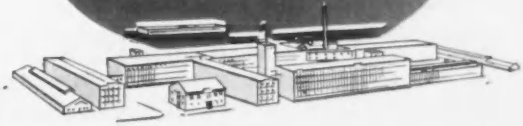
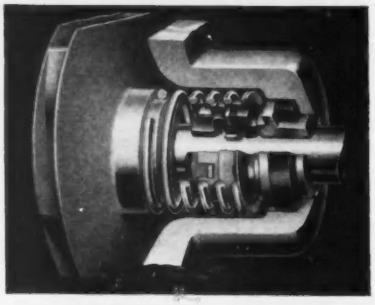
A DIVISION OF THE SESSIONS CLOCK COMPANY, FORESTVILLE, CONNECTICUT



There's a JOHN CRANE Mechanical Seal To Meet Your Exacting Requirements

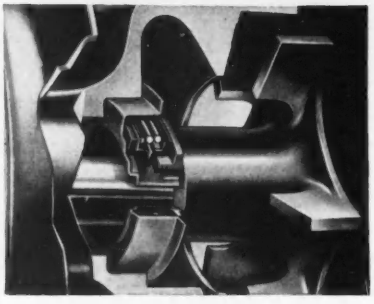
General Purpose Seal...

...most widely used end-face seal in industry... ideal for centrifugal, rotary and jet pumps, gear reducers and many other rotary shaft applications... offers long life, complete flexibility, easy installation. Two types available, No. 1 and 2, for varying equipment space conditions.



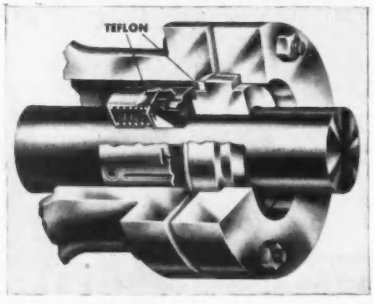
Low Cost, High Quality "Pressed-in" Seal...

...the answer to small shaft sealing applications involving high speeds and vibration. Millions of these Type 6A Seals are mass-produced for automotive water pumps, making them available at a relatively low cost in stock sizes. Each of these easy-to-install seals will fit several shaft sizes since they are "pressed-in" and do not touch the shaft.



High Temperature Anti-Corrosive Seal...

...This Type 9 Seal performs effectively at temperatures up to 485° F. It incorporates a *Teflon* flexible member which is unaffected by all known corrosive agents.



★ ★ ★

All seals in the "John Crane" line are end-face in design ...nothing touches the shaft which can score it. No matter what your mechanical sealing problem is, there's a "John Crane" seal designed to exactly "fill the bill". Our trained field engineers are ready to work with you in selecting the best seal for your needs.

Write for entirely new catalog on "John Crane" Mechanical Seals. It's just off the press!

Dept. PE-7, 1845 Cuyler Avenue, Chicago 13, Illinois.

JOHN CRANE
PACKINGS AND MECHANICAL SEALS
CRANE PACKING COMPANY
CHICAGO
Offices in All Principal Cities in United States and Canada

tions of sulfuric acid. Generally speaking, SR steel alloys range in the "A" classification when exposed to these solutions at room temperature and in the "B" classification when exposed to these solutions at elevated temperatures.

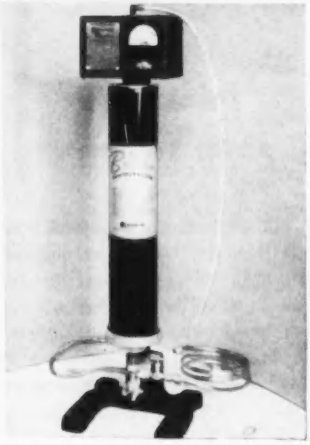
All Super Rustfree Steel alloys are weldable and some types can be used as filler material. SR Steels enable considerable savings in critical materials as they do not contain cobalt, columbium, titanium, zirconium and, in addition, use considerably less nickel than alloys of competitive performance. Competitive in cost to conventional corrosion and heat resistant alloys, including nonferrous alloys.

Uniworld Research Corp. of America, Cleveland 13, Ohio

Direct Reading Demineralizer

The firm's demineralizer is now equipped with a direct reading meter which indicates water purity. It is calibrated in parts per million and also in ohms.

A needle type regulating valve adjusts flow. Also included are a drain



valve and a sturdy base for bench mounting. Base may be removed for wall mounting.

Barnstead Still & Sterilizer Co., 2 Lanesville Ter., Forest Hills, Boston 31, Mass.

Membrane Speeds Up Filtration Process

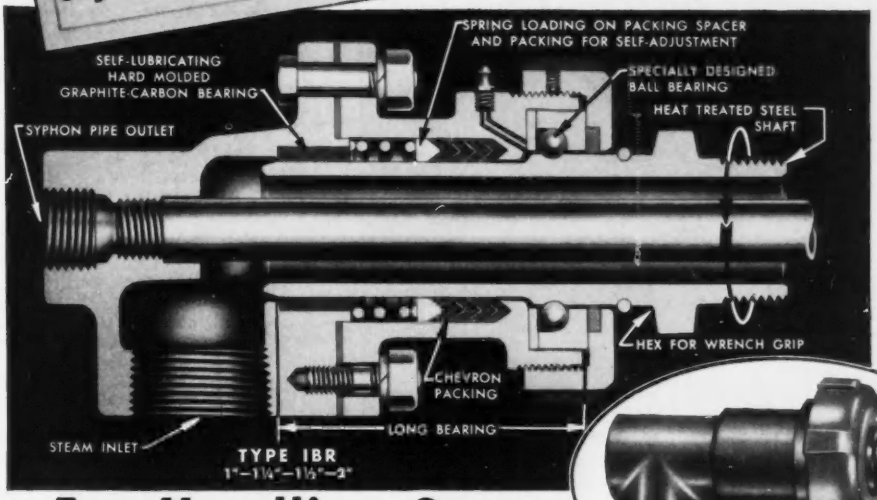
For its line of industrial filters, Titeflex, Inc. has developed a filtering

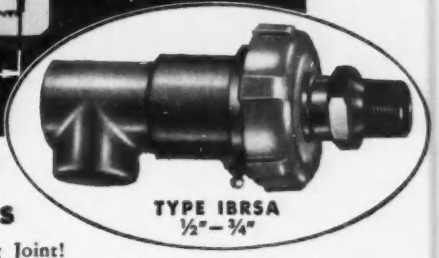
Announcing

The Improved

BARCO

REVOLVING JOINT





For Handling Steam

Water • Air • Oil • Gas

HERE is the new *improved* Type IBR Barco Revolving Joint! Precision-built and field-tested, it has met with enthusiastic approval by machinery designers and operating engineers, alike. Here are some of the reasons why:

LOW TORQUE CUTS POWER COSTS! Wide spacing between bearings holds bearing loads to a low limit and maintains close alignment. Specially designed ball bearing carries both radial and end thrust. Inherent low torque is little affected by pressure, speed, or temperature. Up to 50% power savings.

COMPACT, SIMPLE, LEAKPROOF! Self-adjusting, self-sealing chevron type packing carried under light spring pressure provides a long life seal on specially hardened rotating sleeve, permits remarkably compact construction.

EASY SERVICING, LOW MAINTENANCE! Light running action minimizes wear, permits free-floating installation. No adjusting necessary. Internal parts are readily accessible—usually without removing joint from roll.

For the complete story, send today for new Bulletin No. 300 "BARCO REVOLVING JOINTS." Barco Engineers are at your service; ask for recommendations. BARCO MANUFACTURING CO., 1827-H Winnemac Avenue, Chicago 40, Illinois. In Canada: The Holden Co., Ltd.

Syphon Style—TYPE IBR. Built for 450°F., steam service to 150 psi, and up to 500 RPM. Hydraulic service to 200 psi, 750 RPM. Higher pressure and speeds under certain conditions.

Single Flow Style—TYPE IBRSA. Similar to Type IBR. Sizes 1" and larger have 2-piece flange connected body.

Other BARCO Revolving Joints

TYPE R and RS — Double row ball bearing construction. Maximum pressure 250 psi (steam) or 500 psi (hydraulic). Syphon and single flow styles.

TYPE V — Small size, light duty, for speeds up to 2500 RPM.

BARCO

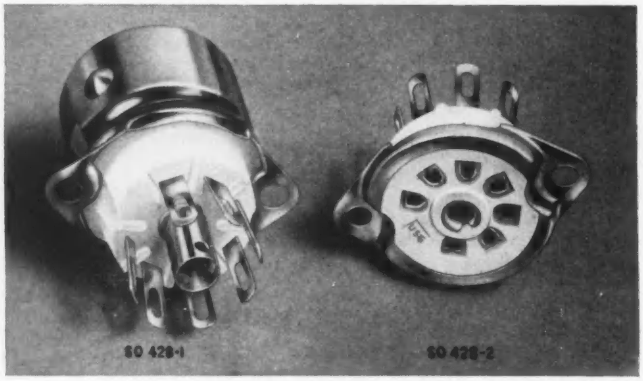
THE ONLY TRULY COMPLETE LINE OF FLEXIBLE, SWIVEL, SWING AND REVOLVING JOINTS

Worldwide Sales and Service

***FREE ENTERPRISE*—THE CORNERSTONE OF AMERICAN PROSPERITY**

first again with TEFLON

7-pin Miniature Tube Sockets, ideal wherever high or low ambient temperatures or frequency stability are problems.



CHEMELEC
HIGH PERFORMANCE
TUBE SOCKETS

Tube sockets are another excellent example of the many unique applications United States Gasket engineers are making with Teflon—the plastic that is:

- **Chemically inert**
- **Mechanically tough**
- **Heat-resistant**
- **Extremely anti-hesive**

Throughout industry, materials men are finding Teflon's combination of properties the answer to tough problems. Teflon expansion joints for corrosion-proof piping systems, Teflon diaphragms, pump cups, stop-cocks, nozzles, Teflon insulators for high-frequency electrical equipment are just a few successful applications of Teflon fabricated by USG.

Teflon is also supplied in sheets, cylinders, rods, tubing and bars.

For complete information write for USG Catalog No. 300.

TEFLON PRODUCTS DIVISION

UNITED STATES GASKET CO.
649 North 10th Street, Camden, New Jersey

membrane constructed of stainless steel wire in the form of a screen of cylindrical shape. Used within the filter itself to support the filter cake, which is the actual filtration medium, the cylinder is said to speed up the filtration process because the triangular cross-sectional shape of the wire prevents clogging. The membrane also aids the backwashing process by which the filter is cleaned without manual labor, because the backwash flow reaches its highest velocity at the exact point of support of the filter cake.

Titeflex, Inc., 500 Frelinghuysen Ave., Newark, N. J.

Potentiometer Has Ultra Low Torque Design

A miniature potentiometer of ultra low torque design measures only $\frac{7}{8}$ in. in diameter (exclusive of the terminals) and only 25/32 in. over-all back-of-panel length, and has a net weight of 0.56 oz. The average starting torque is 0.005 oz-in. at room temperature.

Called the Tinytorque potentiometer, it is available in resistances from 1,000

to 100,000 ohms in single section and ganged assemblies with single or double shaft extensions, and has active electrical rotation of 355 deg and continuous mechanical rotation without stops. Power rating is $\frac{1}{2}$ watt.

Helipot Corp., So. Pasadena, Calif.

Asbestos Gaskets Designed for Rough Or Uneven Surfaces

Designed for service where surfaces are rough or uneven and subject to considerable expansion and contraction, asbestos gaskets constructed of highgrade gasketing materials are used to hold steam, air, water, ammonia, and various other acid and alkali chemicals

DIE CASTINGS BY Stewart

41 YEARS OF SERVICE TO INDUSTRY

MOST MODERN DIE CASTING EQUIPMENT

The name of Stewart is continuously identified with the modern advancements in equipment and procedures that have marked the growth of the die casting industry to its present position as a major production process. Stewart die casting machines are veritable power giants, equipped with precision mechanisms, featuring all modern technological refinements and improvements.

Services available to you at Stewart's

- Designing
- Engineering
- Die Making
- Metallurgical Control
- Most modern Die Casting Equipment
- Complete machining, polishing and assembly facilities

We invite inquiries concerning all Die Casting problems.

STEWART DIE CASTING
Division of Stewart-Warner Corporation
4545 Fullerton Avenue, Chicago 39, Illinois
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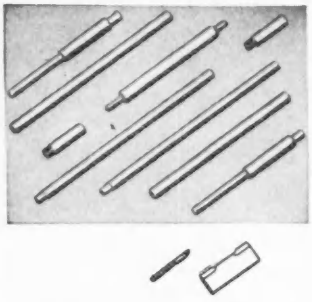
We take pride in being known by the customers we keep

PAY LESS

for precision metal parts made by

TORRINGTON



Low cost for precision quality, fine finish, uniform heat treatment is assured by our high productive capacity and special equipment.

Typical of a wide variety of parts are special rollers, shafts, studs, dowel pins made to order. Chamfer, radius, taper, hemispherical and other styles of ends. Rollers from .014" to .500" diameter. Centerless ground .040" to .500"; diameter tolerance ±.0001". Finish as fine as 3 micro-inches. Dowel pins from .0625" to .3125".

We are also set up to make such parts as surgical and dental instruments, pen and pencil barrels, soldering iron cases, special needles, instrument shafts and pivots, screw driver and ice pick blades, knurled mandrels or spindles, etc.

Send your prints and specifications today for prompt quotation.

THE TORRINGTON COMPANY
Specialty Department
554 Field Street • Torrington, Conn.

Makers of
TORRINGTON NEEDLE BEARINGS

New Parts and Materials.....continued

in storage tanks, cookers, dryers, laundry machinery, locomotives, tank cars, boilers and locomotive service. On standard sizes, flanges are 3/16 in. thick and 7/16 in. wide or larger. Inside diameters are from 2½ to 18 in. Special gaskets of larger sizes, and square or oval gaskets, are made promptly to order. Irregular shapes, and bolt holes, etc., are supplied according to customer specifications.

Lawton H. Parsons, 6 S. Main St., Ambler, Pa.

Syncromount Potentiometer Saves Space

Long life and a low torque shaft mounted in ballbearings are features of the "Syncromount" potentiometer. The shaft, with runout and concentricity within 0.001 in. of the syncro type mount, enables this potentiometer to be driven directly in a precision computer gear train. Its small size (1½ in. diameter) makes it ideal for applications in guided missiles and aircraft installations where space is at a premium. It can be furnished with linear or functional output. The total resistance can be as high as 100,000 ohms and torque less than 0.2 in.-oz.

G. M. Giannini & Co., Pasadena, Calif.

Aluminum Pigment Simulates Chrome

A special, extra-fine aluminum lining pigment is claimed to be capable of producing films of chrome-like appearance. Particularly recommended for automotive hardware, its appearance is said to be as near to chrome as is possible to obtain with a metal pigment.

The new product, it is stated, provides a degree of improved dispersi-

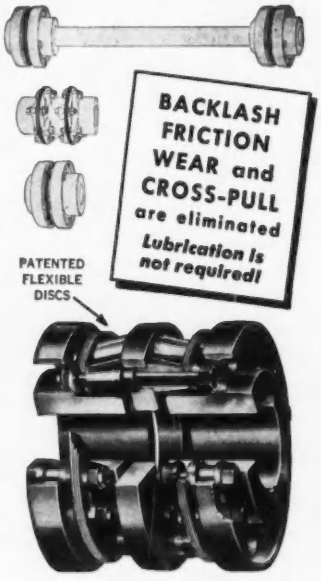
THOMAS Flexible ALL METAL COUPLINGS

FOR POWER TRANSMISSION
REQUIRE NO MAINTENANCE

Patented Flexible Disc Rings of special steel transmit the power and provide for misalignment and end float.

Thomas Couplings have a wide range of speeds, horsepower and shaft sizes:
½ to 40,000 HP
1 to 30,000 RPM

Specialists on Couplings for more than 30 years



THE THOMAS PRINCIPLE GUARANTEES PERFECT BALANCE UNDER ALL CONDITIONS OF MISALIGNMENT.

NO MAINTENANCE PROBLEMS.

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THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA

On Battle Roads or Highways
ELASTIC STOP NUTS
Guarantee Tight Fastenings

Rough terrain and rough handling are hazards to the world famous military 'Jeep'. That's why Willys builds its 'Jeeps' and other vehicles with Elastic Stop Nuts at important points to eliminate fastener failures due to vibration.

In this vehicle the famous Red Locking Collar of the Elastic Stop Nut holds firm against vibration—reduces maintenance—on vital applications such as: accelerator hinge, universal joints, body hold down, spring shackles, radiator hold down, and air cleaner. The Red Collar grips bolt threads firmly—protects against vibration, impact, and stress reversal—prevents freezing of nuts to bolts by protecting internal bolt threads against corrosion.

Check the advantages of Elastic Stop Nuts against any other type of self-locking fastener. You'll find that only ESNA offers a complete line of thread sizes and varied nut types engineered to simplify your assembly line fastening problems and to provide your customers with maintenance-free operation.

Whether you are manufacturing equipment for rough military use or designing better performance and easier maintenance into equipment for your normal market . . . use vibration-proof fasteners. Now is the time to get full information. Write for complete product line bulletin to Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, N. J.

DESIGN AHEAD WITH ESNA

THE FAMOUS RED ELASTIC COLLAR IS VISIBLE EVIDENCE OF LOCKING SECURITY

Threadless and permanently elastic, it provides these 4 outstanding features:

1. Protects against nuts loosening due to VIBRATION
2. Keeps locking threads CORROSION FREE
3. Provides for accurate BOLT LOADING
4. Seals against LIQUID LEAKAGE along the bolt threads

And can be used again and again

ESnail® ESNA ROLLPIN

ELASTIC STOP NUTS

DESIGN HEADQUARTERS FOR SELF-LOCKING FASTENERS

YOU may telescope the distance from blueprint to sales

...by calling on your plastics molder's know-how

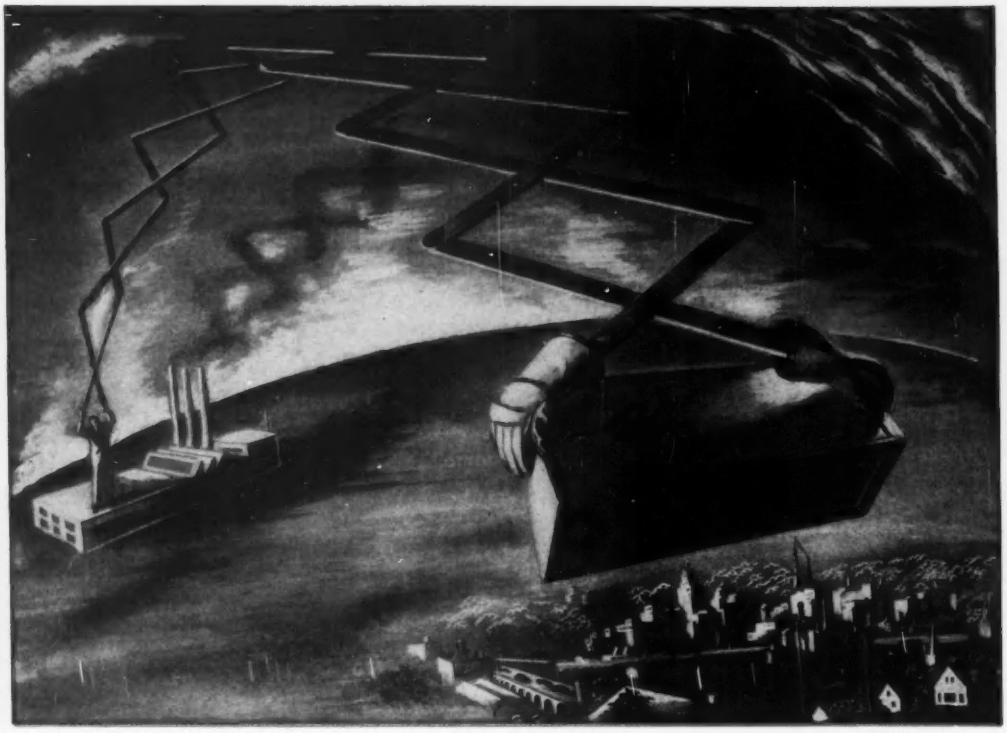


Figure it every way—in time, tooling costs, manpower need—there's a lot you may save by talking things over with a custom molder of Durez plastics.

Your molder can often see an opportunity to use plastics that is not apparent on the surface. Representing a mature industry, he is equipped to take hold on jobs involving plastics alone or in conjunction with other materials, and carry them through to completion with time-saving dispatch.

Accustomed to serving leading manufacturers in many fields, molders maintain highly competent design, engineering and production staffs. They hasten to adopt the newest in equipment and methods in the interest of low delivered cost.

Perhaps most valuable of all is the knowledge of plastic materials your molder uses in interpreting your needs. When resistance to heat, moisture, or chemicals is required, plus impact strength, unusual electrical properties, and high surface lustre, he recognizes the advantages of Durez phenolics. Because he knows them well, he can specify the one that best fits the job.

All the assistance the Durez staff can lend you and your molder in furthering your product plans will be given gladly. Offices in leading cities.

Our monthly "Durez Plastics News" will keep you informed on industry's uses of Durez. Ask us to send a copy regularly. Durez Plastics & Chemicals, Inc., 2007 Walck Road, North Tonawanda, N. Y.

DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- PROTECTIVE COATING RESINS

PHENOLIC PLASTICS THAT FIT THE JOB

bility not otherwise obtained. When combined with the proper vehicle, mixtures made with it are practically free of agglomerated particles, and a high degree of smoothness and leveling are obtained.

A leafing type pigment, the aluminum paste contains 65 percent nonvolatile content. Screen tests show 100 percent through 325 mesh.

Metals Disintegrating Co., Elizabeth, N. J.

Small Vacuum Pump Displaces 2 Cfm

Designed for portability, a small vacuum pump capable of producing high vacuums rapidly and dependably, employs an oil-sealed pumping system. The complete unit, including ½ hp motor, base, and pump, weighs 70 lb

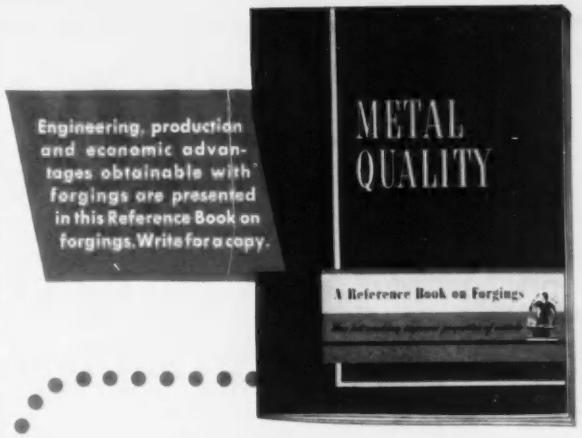
and has a free air displacement of 2 cfm. The compound pump produces McLeod gage absolute pressure readings of 0.1 micron or better, and is said to retain high percentage of its volumetric efficiency in the low pressure regions. It has applications both in research and in production—for lamp and tube manufacturing, for laboratory applications, and for backing diffusion pumps.

Kinney Mfg. Co., 3529 Washington St., Boston 30, Mass.

Worm Drive Hose Clamp Features Snap Lock

The Ideal Snaplock, a new type of worm drive hose clamps, features unique "snap-lock" clamping action and open end design that speed installation or removal. The clamp action also is said to ensure a lock-fast grip on all hose from ½ in. to 3 in diameter.

The Snaplock employs the worm drive principle and consists of perforated band, mating worm drive screw, and screw saddle, with the screw so set as to permit swivel action. When the screw is tipped up to vertical position, the clamp snaps open


Engineering, production and economic advantages obtainable with forgings are presented in this Reference Book on forgings. Write for a copy.
METAL QUALITY
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Never underestimate the preference of users of your product for the factor of greater safety that is inherent in forgings. This factor of greater safety results from toughness and strength, in correct proportion, as found only in closed die forgings. Consult a forging engineer about the mechanical properties required for your product.

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for remarkable U. S. Royalite the Versatile Thermoplastic

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Auto Fender Stone Guard
In this application, Royalite's toughness, hardness and ability to withstand great impact without splintering make it especially valuable in the automotive industry.

There is virtually no end to the uses of U. S. Royalite. Designers and engineers say it gives them new freedom of design, lets them attain an efficiency often never possible with any other thermoplastic.

Royalite is obtainable either standard or flame-resistant. It can be sawed, sheared, sanded, punched, nailed, bolted, riveted, sewed and cemented. Stiff or flexible, hard or soft, it can be formed on standard equipment with conventional techniques. The engineering staff of United States Rubber Company will be glad to work with you or advise you on any application of Royalite you may suggest.

ROYALITE IS:

- ★ Standard or flame-resistant
- ★ Lightweight
- ★ Non-splintering
- ★ Non-Warping, non-corrosive
- ★ Tough
- ★ Highly resistant to impact
- ★ Waterproof, stainproof
- ★ Not affected by oils, most acids, alkalies
- ★ Available in different colors, for easy classification
- ★ Stable under changing atmospheric conditions
- ★ Exceptional electrical insulating properties
- ★ Low rate of heat conductivity

ROYALITE
Shaved Ice Chute
Light in weight, non-warping, waterproof—this unique molded ice chute is perfect for the job. Fabricated by Regal Plastics Co., Kansas City, Missouri.

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STANDARD OR FLAME RESISTANT

SEE NEXT PAGE FOR LIST OF U. S. ROYALITE FABRICATORS ➡

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Swedlow Plastics Co., 5527 District Blvd., Los Angeles 22
Westwood Craftsmen, Inc., 2043-45 Pontius Ave., Los Angeles 25
Associated Mfg. Co., 541 S. Fair Oaks Ave., Pasadena 2

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Gladwin Plastics, 542 Courtland St., N.E., Atlanta

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MICHIGAN
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Fabri-Kal, 242 East Kalamazoo Avenue, Kalamazoo
Woodall Industries Inc., 7565 E. McNichols Rd., Detroit 34

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Plastics, Inc., Chestnut & Ryan Sts., St. Paul 2

MISSOURI
Regal Plastics Co., 710 Main St., Kansas City

NEBRASKA
Omaha Plastics Co., 1470 S. 16th St., Omaha 9

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Stokes Molded Products, Inc., Taylor St. at Webster, Trenton 4
Thermacote Co., 320 Jefferson St., Newark 5
Van Beek Industries, 23 Park St., Orange

NEW YORK
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Dual Fabricators Corp., 808 Driggs Ave., Brooklyn 11
Dura Plastics Inc., 1 W. 34th St., New York 1
Durable Formed Products, Inc., 329 Canal St., New York 13
Mastercraft Plastics Co., Inc., 95-32 150th St., Jamaica 4
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The Bell Plastics Co., Inc., 600 Heinz Street, Pittsburgh 12

TENNESSEE
Plasti-Line, Inc., Jacksboro & Broadway, Knoxville 18

TEXAS
Plastic Engineering Co., 2101 69th St., Houston 11
Plastic Products of Texas, 1400 Cedar Springs, Dallas

WASHINGTON
K. B. Plastics, Inc., 1817 So. 1st St., Yakima
Mason Plastics Company, 1121 Westlake North, Seattle

WISCONSIN
Midland Plastics Inc., 227 N. Water St., Milwaukee 2

The United States Rubber Company at 2638 North Pulaski Road, Chicago, Illinois, has complete Engineering, Designing, and Styling Departments to assist fabricators on the technique to employ, and in the art of fabricating most efficiently with ROYALITE.

(1) permitting clamp installation with hose in position. The band is then clamped around hose and the end brought through the saddle to a snug fit. The screw can then be snapped down to original horizontal position to lock clamp in place. (2) With a few turns of the screw, the clamp is tight. (3) A secure grip is positive under the most severe vibration.

To remove the clamp, the worm drive screw must first be loosened with a screw driver. Only then can the screw be tipped up. Doing so snaps the clamp open for easy removal.

The Snaplock was developed originally for aircraft but has already found extensive application beyond that, notably in the automotive field.

Screw, screw saddle and band are heat treated and are plated to resist corrosion.

Ideal Corp., 435 Liberty Ave., Brooklyn 7, N. Y.

Tachometer Measures Wide Speed Ranges

A three-range, single-head, fixed installation tachometer indicator is available for speed measuring applications where a particularly wide range of speed measurement is desired.

Simple rotation of the indicator knob selects one of three speed ranges to measure any speed over a total range of 40 or 50 to 1, based on readings down to 1/10 full scale of the lowest range. The ranges are carefully chosen for ease in reading, and the scales are all 4 in. long with 100 divisions. Indicator calibration is stable indefinitely and good over a wide temperature range. However, calibration is easily adjustable in the field. Scales are supplied for direct reading in any units such as rpm, fpm, ips, or in any quantity which is proportional to the speed actuating the head. Various

SPEED ALLOY
hot rolled ALLOY STEEL PLATE

This STEEL is a "STEAL"
when you consider the savings

IT sounds incredible that an alloy steel of Rockwell C 35 could be machined with a surface speed of 250 f.p.m. or more. Eagle Tool & Machine Co., Newark, N. J. readily cut SPEED ALLOY at that high rate of speed on their Cincinnati Hydrotel duplicating machine. Eagle feels that the easier machining qualities of this steel enable them to cut cavities for plastic molds at such low costs that results obtained are unequaled by other materials or methods.

On the cavity force, shown above, for molding a large home freezer breaker frame, SPEED ALLOY plates 5" x 32" x 62", were furnished heat treated to Rockwell C 35. Cavity was machined to 1" depth. Roughing cut was made with 5" milling cutter, cutting in full diameter to depth of ¼" with feed of 7" per minute; a maximum of 8¾" of steel removed per minute. By using pre-hardened steel there was no distortion due to subsequent heat treatment. Machined finish was like a mirror. Considering the initial low cost, machining costs and longer tool life, SPEED ALLOY is a "Steal"!

Speed Alloy Cams Carburized and Hardened With Practically No Distortion

This paper box machine cam is ⅞" thick, has track 1⅛" deep and 1¼" wide, leaving web only ⅜" thick. This is ample because of SPEED ALLOY'S high tensile strength and wear resistance. Despite thin web section cams were carburized and hardened with distortion held to .002" to .003". Made by S & K Tool & Die Company, Kalamazoo, Mich.

Since 1856

W. J. HOLLIDAY & CO. (INC.)

SPEED STEEL PLATE DIV.
120 139th St., Hammond, Ind.
Plants: Hammond and Indianapolis, Indiana

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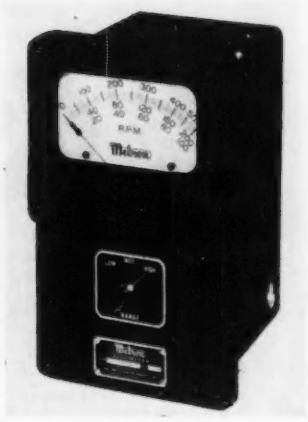

tachometer heads permit direct measurement ranges from speeds between ½ rpm and 100,000 rpm without requiring a speed changing drive.

The indicating meter is of rugged design and is mounted in sponge rubber. With ordinary open wires, the indicator can be located up to 1,000 ft from the head without materially affecting calibration. Selection of the wrong range or otherwise overspeeding does not damage the indicator.

Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.

Direct-Reading Capacitance Meter

Small values of direct capacitance are read directly on a self-contained, a-c operated, 4-in. indicating instrument having a logarithmic scale. Full scale ranges are 0.1, 1.0, 10, and 100 $\mu\mu$. Absolute accuracy is better than 5 percent and reproducibility is better than ½ percent. Calibration is by means of a built-in standard.

A percent-limit indicator can be made part of the instrument. Measurements are made at 500 kc. Power factor is not measured; losses at power factors below 0.05 have negligible effect on capacitance readings. Variations in 60-cycle line voltage, from 95 to 135 volts, do not affect the accuracy of measurement.

The instrument is contained in a relay-rack cabinet with panel 10½ by 19 in.; it weighs about forty pounds. Standard BNC fittings are provided on the panel for connection of the two 16-in. test cables furnished with the instrument.

MacLeod and Hanopol, Inc., 10 Joiner St., Charlestown 29, Mass.

SPONGEX®

cellular

rubber

Prevents Frosting

And Sweating

"A-P Valve Insulator courtesy of A-P Controls Corporation, Milwaukee, Wisconsin."

Custom molded in one piece, Spongex cover opens, snaps closed around valve.

When this expansion valve is installed outside of low temperature apparatus a custom molded *Spongex* insulator prevents dripping which otherwise would damage the floor or equipment beneath. Besides its special shape the requirements of this part called for cellular rubber of interconnecting cell structure with natural skin on all exposed surfaces.

For many manufacturers, conversion is bringing new and different requirements for materials. Your needs in cellular rubber might call for **SPONGEX** similarly molded. Or a die-cut shape. Or a standard cord, tube, strip or sheet. Perhaps you seek the 0.28-0.30 K insulating factor of **SPONGEX CELL-TITE®** or the efficiency of **SILICONE SPONGEX** at −100° F to 450° F Spongex stands ready to help you solve any problems you may have.

This new booklet on the properties of, test data on, and specifications for cellular rubber has just been released. It's concise, and a valuable reference source. Write for a free copy today.

The World's Largest Specialists in Cellular Rubber.

THE SPONGE RUBBER PRODUCTS COMPANY

402 DERBY PLACE **SHELTON, CONNECTICUT**

how to FEED MATERIALS ECONOMICALLY: use GAST rotary AIR PUMPS!

This unit, for example, seals milk bottles with Alumo-SEAL aluminum caps . . .

PROBLEM: Remove caps one-at-a-time from magazine, and hold ready to drop into feed chute.

SOLUTION: Suction cup with 20" to 22" vacuum, produced by positive-action Gast Rotary Air Pump.

RESULT: Dependable, low-cost operation from portable Gast unit in housing on floor.

Just for a moment, consider how you could apply low vacuum for feeding sheet materials and small parts of paper, fibre, plastic or light metal.

The possibilities are enormous for extra speed — extra savings — extra safety. And Gast Rotaries are giving excellent service on scores of common — and unusual — applications.

When you have problems that might be solved with low vacuum or pressure, write Gast. "Air may be your Answer!"

SEE OUR CATALOG in SWEET'S FILE

Gast Application Ideas Booklet — showing 26 design problems solved — sent upon request.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

AIR MOTORS · COMPRESSORS · VACUUM PUMPS

(TO THREE H.P.) (TO 30 CFM.) (TO 28 INCHES)

GAST MANUFACTURING CORP., 139 Hinkley St., Benton Harbor, Mich.

MEETINGS

June 17-July 3

JAPANESE TRADE FAIR—Edmundson Pavilion, University of Washington, Seattle, Wash.

July 2-4

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS—Semi-Annual Meeting, Hotel Multnomah, Portland, Oregon.

July 30-August 2

AMERICAN ELECTROPLATERS' SOCIETY—Buffalo Convention, Statler Hotel, Buffalo, N. Y.

August 13-15

SOCIETY OF AUTOMOTIVE ENGINEERS—West Coast Meeting, Olympic Hotel, Seattle, Wash.

August 20-23

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Pacific General Meeting, Portland, Oregon.

August 22-24

INSTITUTE OF RADIO ENGINEERS—Western Convention and Seventh Annual Pacific Electronic Exhibit. Civic Auditorium, San Francisco, Calif.

August 27-30

ILLUMINATING ENGINEERING SOCIETY—Hotel Shoreham, Washington.

September 2-7

LEIPZIG FAIR—Leipziger Messeamt, Leipzig C1, Platz des Friedens 8, Deutsche Demokratische Republik.

September 4-7

AMERICAN MATHEMATICAL SOCIETY—Fifty-Sixth Summer Meeting, University of Minnesota, Minneapolis.

September 10-14

INSTRUMENT SOCIETY OF AMERICA—Sixth National Instrument Conference and Exhibit, Sam Houston Coliseum, Houston, Texas.

September 10-13

SOCIETY OF AUTOMOTIVE ENGINEERS — Tractor and Production Forum, Schroeder Hotel, Milwaukee.

October 8-12

NATIONAL HARDWARE SHOW—Grand Central Palace, New York.

October 15-19

NATIONAL METAL EXPOSITION & CONGRESS — Michigan State Fairgrounds, Detroit, Mich.

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ELECTRUNITE TUBING *Eases Life-*

FOR THE MANUFACTURER...

FOR THE PATIENT...

HOSPITAL PATIENTS can relax in every position, from full-reclining to upright, in this sturdy rejuvenating chair made by Barcalo Manufacturing Company. Steel tubing provides the stiffness and rigidity to make the chair steady and reassuring to the patient, yet light to move.

The manufacturer likes the way ELECTRUNITE Steel Tubing works on this application. Uniform ductility and wall thickness assure rapid, predictable forming and bending of the tubes to shape. Where tube ends must be fully flattened at joints, there's no trouble with cracks and fractures. The excellent surface of this ELECTRUNITE Tubing requires no special handling or trick treatments to hold long-lasting finishes under severe service.

Have you considered using ELECTRUNITE Steel Tubing in your essential products, such as these invalid chairs? We'll be glad to discuss your problems . . . and offer you the benefits of Republic's 3-Dimension Metallurgical Service. It's the helpful service that focuses the knowledge and experience of field, mill, and laboratory metallurgists on your fabrication problems.

REPUBLIC STEEL CORPORATION
STEEL & TUBES DIVISION
224 EAST 131st STREET
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Republic REPUBLIC STEEL
ELECTRUNITE TUBING

AN approved (3303-1)

R-B-M

ELECTRONIC AND COMMUNICATION RELAYS

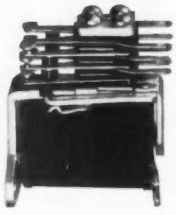
Now Hermetically Sealed

HUNDREDS of thousands of R-B-M telephone type relays saw Government service in World War II. Now most of these relays are available in hermetically sealed enclosures designed to meet AN specifications.

R-B-M hermetically sealed telephone type relays are available in contact forms up to and including 4-pole, double throw, 3 ampere, 28 Volts D. C. construction. Also 10 ampere rating up to and including 2-pole double throw at 28 Volts D.C. All relays available with approved AN plug connector, or with solder connections.

Engineers! What is YOUR hermetically sealed relay requirement? R-B-M is developing new and smaller relays to meet Armed Services requirements. Perhaps one of these will solve your problems. Write giving complete relay specifications, application, quantity and AN specifications applying. Address Dept. C-7.

AN approved (3304-1)



R-B-M Production and Engineering facilities in two plants, located in different states, (over a quarter million square feet), can assist you in the development and production of special electro-magnetic devices for Armed Services application.

RBM

R-B-M DIVISION
ESSEX WIRE CORP.
Logansport, Indiana

MANUAL AND MAGNETIC ELECTRIC CONTROLS
—FOR AUTOMOTIVE, INDUSTRIAL, COMMUNICATION AND ELECTRONIC USE

Sans, Souci

Ad Libbing by the Editor

During this past month I have gotten a few letters from readers wanting to know "Who writes Sans, Souci, anyhow?" Then I saw that in the June number we even omitted the above highly ambiguous by-line, "Ad Libbing by the Editor." On top of that some of my associates and finally the boss started to razz me and asked if I was afraid to sign my name. But I am stubborn, so for the time being, at least until my boss Hop hops me some more, I'll just sign these things —with my initials.

Last month I said something about the lack of understanding of elastic modulus. Then when it was too late to add anything to the column I happened to remember the incident about Fred Bowers, master mechanic of Harrisburg Steel Company, at that time known as the Harrisburg Pipe and Pipe Bending Company.

Fred Bowers was a great character. Everybody liked him. I guess that was because he liked everybody. Fred also knew his job and carried in his head a tremendous fund of facts and figures, for which he was highly respected.

One day I was in Fred's office when a man came in with a requisition for Fred to approve for a $\frac{5}{16}$ round bar of cold rolled, about 20 ft. long. The man got the O.K. and a few minutes later we saw him walking by outside the office with the bar over his shoulder.

"Huh!" exclaimed Fred. "The store keeper gave him a $\frac{1}{4}$ in. round instead of a $\frac{5}{16}$ round." Events proved that Fred was right.

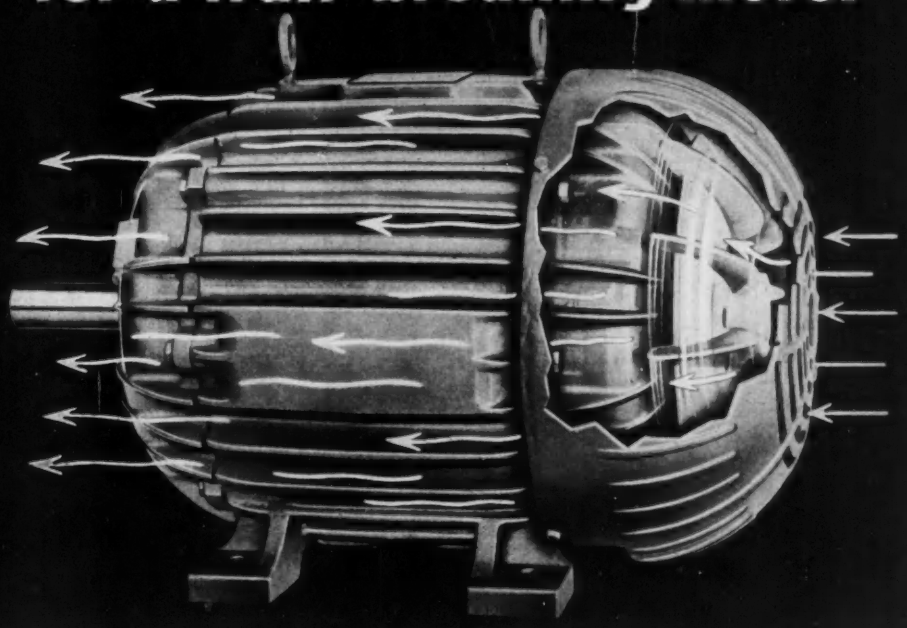
For some time I wondered how Fred knew it. At last I had to ask him. His answer was:

"The bar drooped to much for a $\frac{5}{16}$ in. and not enough for a $\frac{3}{16}$, so I knew it had to be a $\frac{1}{4}$ in. round."

How simple. Figure it out and you can see with half an eye the great difference in the sag or droop of the three different sizes of bars. I'm too lazy to figure it out, but off hand the $\frac{3}{16}$ round will sag almost twice as much as a $\frac{1}{4}$ round and almost three times as much as the $\frac{5}{16}$ round.

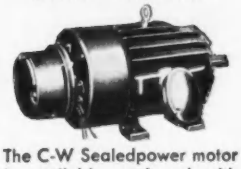
The other day I had a visit from my good friend Ed Hurst who is vice president of United Cotton Products Company, Fall River, Mass. I have known Ed for many years and we have often had interesting discussions of this that and the other thing. However, on this particular visit my good

TENTH ANNIVERSARY
for a trail-breaking motor



THE ELLIOTT CROCKER-WHEELER
Sealedpower MOTOR

SEALEDPOWER BRAKE MOTORS



The C-W Sealedpower motor is available equipped with the newly designed C-W Brake, providing increased brake capacity without increased bulk.

The Elliott C-W Sealedpower motor is available also in explosion-proof construction. Bulletin SL-300-5 covers this type. Copy on request.

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friend Mr. Hurst had something very specific to talk about. He was greatly perturbed about the subject of "servo mechanisms". He could not understand the nomenclature, he said. And that started me thinking and digging around, particularly in the printed literature. I soon became aware of the fact that servo mechanisms were going through the patent medicine stage.

On the face of it there does not seem to be any connection between patent medicine and "servo mechanisms". But let me explain. A patent medicine is launched upon the market as a sure cure for let's say rheumatism, but soon its acclaimed field of usefulness is extended. What started as a rheumatism medicine soon becomes a claimed cure for coughs, tuberculosis, migraine headaches, corns and bunions, and may even be recommended as a good "pick me up" for the morning after the night before. Of course, the vendor dare not be too explicit in his claims and, therefore, to make them very ambiguous he initiates a new vocabulary, throws in a lot of misplaced adjectives and depends upon the gullible public to swallow both the sales propaganda and the medicine.

In going through some of the literature on "servo mechanisms" I observed somewhat the same tendency. What is now known in many cases by the misnomer "servo mechanisms" is not really new. It is at least 75 years old and perhaps much older. I first observed it many years ago in the control of the steam driven steering engines used on ships.

When the helmsman turned the steering wheel he caused the rotation of a screw on the engine frame. The screw passed through a nut and the travel of the screw shifted the steam valve, thus causing the engine to rotate in one direction or the other. The nut was cylinderical in shape with a thread on the outside surface which engaged a threaded sleeve which was rotated by the engine. Rotation of the sleeve by the engine caused the nut to travel linearally, carrying the screw back towards its original position which put the valve back on dead center and thus stopped the engine.

The word "Servo" came into existence only a few decades ago as a copyrighted trade name of an automobile brake. Subsequently the word came into more general use and is now defined as a generic term in Webster's dictionary as "Any power driven mechanism which supplements a primary control." Webster also gives the definition: "Servo motor—an auxilliary motor regulated by a hand lever for quickly and easily moving the

reversing gear of a large marine engine into any desired position indicated by that of the hand lever which controls the valve of the motor."

Today we see the principle of the marine steering engine control vastly extended. In addition to marine engines, servo motors include air, hydraulic, and electric power units. The application is no longer restricted to the marine field. Aircraft, machine tools, trucks, valves and numerous other machines and devices are now "servo" controlled. The servo control system is any control system wherein the finally controlled element is caused to move into any desired position as may be indicated by the displacement of the primary controller, through the medium of some type of linkages or media that control the servo motor.

Unfortunately, many technical writers refer to servo control systems as servo mechanisms. Obviously that is incorrect nomenclature. Most servo control systems involve many mechanisms, power units and other elements. A complete servo control system is much more than just a mechanism.

If the enthusiastic experts of servo mechanisms are sound in their interpretation and if we accept their nomenclature as basically correct, we must conclude that the handle on a faucet, the stem winder on a watch, the electric push button and the clutch lever in a mechanical transmission are all servo mechanisms or servo controls.

I once met a man who claimed to be the country's expert on gear design. Now I am not an expert on gear design, but I have had many interesting discussions on the subject with quite a few of the authorities in that field including Louis Martin, Allan Candee, Earl Buckingham and a few others. I at least understood their nomenclature and their english even though I might not have the full appreciation of an expert on the fine points of the design. But this other fellow who claimed to be the country's expert had a vocabulary all his own. He had another name for everything and I never knew what he was talking about. It finally dawned on me that he did not know what he was talking about himself and that he was sounding forth with unknown nomenclature with the hope nobody else would understand. Thereby he had no fear of being disputed.

Anyhow, I think some organization should get on the job and develop a logical nomenclature for servo control systems. The Machine Design Division of the ASME would be a logical body.

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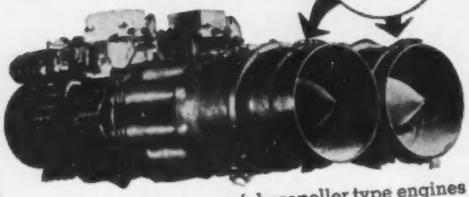

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ENGINEERS' NOTEBOOK

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Sans Souci .....continued

menclature. It reminds me of an ordinance relating to dogs passed by the Council of the City of Summit, New Jersey. In typical legal fashion the ordinance begins with a definition of a dog as follows: "The dog shall be any dog, or a bitch, or a spayed bitch." Well that struck me funny so I made some wise cracks about it to my good friend Bill Stuart editor of "Electrical Construction and Maintenance", who happens to be a dog fancier. He smiled and said "The ordinance is correct if you accept the definitions set forth by the Dog Fanciers' Association, or whatever it is called. Only male dogs are dogs and female dogs are always called bitches, and nothing else. Obviously, the ordinance would not be sufficiently specific if it did not differentiate accordingly." So I had to admit that maybe the lawyers are right.

Recently one of my friends in the International Acetylene Association sent me a very fine book called "Man Does Not Stand Alone," written by the late Cressy Morrison, who served as president of the New York Academy of Sciences, was a life member of the Royal Institution of Britain, and had many other honors bestowed upon him. It is a fine book and contains much food for thought. Here is one of the gems—"The unknown increases in arithmetical progression as each unit of knowledge is acquired by man."

It doesn't take much thinking to realize the great significance of this statement and how obvious is its truth. The discovery of induced electricity raised the curtain on the vast, then unknown, field of electricity; the discovery of alpha and beta rays opened the door to electronics. Today we stand aghast at the vastness of the field of unknowns ushered in by the discovery of atomic fission.

We only have to look back less than two decades when men of little faith attempted to convince the people that, "The days of pioneering are over, there are no more new fields of science and industry to discover. We have reached the last frontier. From now on the only great task will be to solve the social problems." Just about ten years later the awful blast at Hiroshima exploded this myth so effectively that those who had propounded the false philosophy denied that it had ever existed. In the final analysis I guess those boys are correct. It wasn't a philosophy, it was merely political propaganda, for which a more suitable name is hokum, or perhaps better still, patent medicine.

And in conclusion, here go my initials. —G. F. N.

ENGINEERING ABSTRACTS

Buckling of Springs

Abstracted from "Instability of Springs" by J. A. Haringx, Philips Technical Review Feb. 1950, p 245.

THE COMPRESSIVE INSTABILITY of rods, plates and thin-walled cylinders is generally well known. For example, a straight rod loaded axially remains straight until the critical compressive load is reached, then it suddenly deflects laterally. This critical load is given by Euler's equation:

$$P_{cr} = \pi^2 \frac{EI}{l^2} \qquad (1)$$

and the critical compressive deformation,

$$\xi = \frac{\Delta l}{l} = \frac{P_{cr}}{EA} = \frac{\pi^2}{16}\left(\frac{d}{l}\right)^2 \qquad (2)$$

for a simply-supported cylindrical rod of diameter d and length l.

Helical Compression Springs

Helical springs can also buckle under compressive forces, but here the relationship is not as simple. In this case, the critical relative compression has been derived for springs with their ends hinged or constrained parallel:

$$\xi = 0.8125\left[1 \pm \sqrt{1 - 6.87\left(\frac{D}{l}\right)^2}\right] \qquad (3)$$

where ξ is the deflection ratio or $\Delta l/l$; Δl is the deflection; l is the length of the spring in the unloaded state and D its diameter. See Fig. 1.

Just as in the case of the rod, Young's modulus of the material has disappeared from the formula and the critical relative compression depends only upon the ratio of the length to the diameter and upon the manner in which the ends are fixed. With the helical spring, however, this is much more striking than in the case of the rod, because it means that neither the diameter of the wire nor the pitch or number of coils has any effect upon the buckling phenomenon.

Eq (3) is plotted in Fig. 1 and illustrates that there is a certain critical slenderness below which the spring does not buckle. For spring ends that are hinged or constrained parallel, the critical value is $l/D = 2.62$; this value is 5.24 if the ends are clamped. From this curve, small variations in the slenderness gives rise to great dif-

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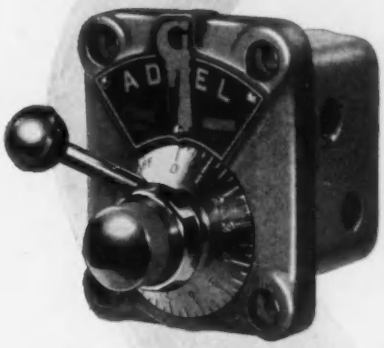

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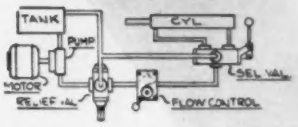

Diagram illustrates typical circuit showing control of cylinder.

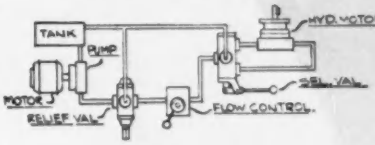

Diagram illustrates typical circuit showing control of hydraulic motor.
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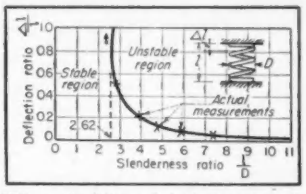

FIG. 1—Buckling of helical springs is dependent on the slenderness ratio. For hinged ends (or constrained parallel), the critical value is 2.62; for clamped ends, the curve would be identical, but $l/D = 5.24$.

ferences in behavior. For example, if the critical value is only slightly exceeded, buckling may occur when the spring is compressed to half its original length. This is shown in Fig. 2

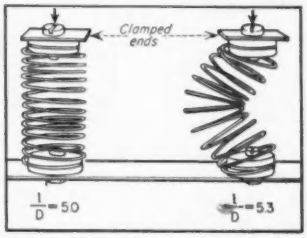

FIG. 2—Two springs of the same initial length but differing slightly in wire size illustrate the effect of a small change in the slenderness ratio above the critical value. Both springs are compressed 60 percent.

for a spring with clamped ends. The spring at the right has buckled since the ratio l/D is 5.3 which is slightly above the critical value of 5.24.

Rubber in Compression

The critical compression of a rubber rod of circular cross section with the ends hinged or constrained parallel can be calculated by

$$\xi = \frac{1}{1 + 1.62\,(l/d)} \qquad (4)$$

This equation corresponds to that of Eq (2) and similarly depends on the slenderness ratio. The curve Fig. 3 illustrates this relationship. It may be seen that for values below $l/D = 0.6$, there is no possibility of buckling. This relationship proves to be particularly good since the elastic properties of highly compressed rubber are difficult to express in a formula. In this case, when the compression approaches 50 percent, or $\xi = 0.5$, the formula is not unreliable.

Flat Spiral Springs

If a spiral spring is wound a criti-

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(2) ROLLER BEARINGS—Shafer Bearing Corp. Catalog No. 51, 56 pp. This catalog describes and illustrates the full line of the company's products including pillow blocks, take-up units, flange cartridge units, cartridge units, duplex units, take-up and frame units plus unmounted roller bearings. Complete engineering and load rating data are included.

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(29) MOTOR CONTROLS—Allen-Bradley Co. Catalog, 92 pp. This illustrated catalog contains information, dimensions and prices of the company's line of motor controls. A special a-c and d-c index along the page margins provides ready reference.

(30) ELECTRONIC EQUIPMENT—Milo Radio & Electronics Corp. Catalog, 1053 pp. This illustrated booklet lists the products of the major radio-electronic equipment manufacturers, with prices and discounts. Distribution of this booklet is necessarily limited to authorized engineering or research department heads who make request on company letterhead.

(31) METALLOGRAPH—F. T. Griswold Mfg. Co. Bulletin, 4 pp. This bulletin describes the OPL Metallograph, a basically new concept in precision and convenience for laboratory determination. Structural and optical features of this compact and simple instrument are discussed and illustrated.

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(33) GOVERNMENT SPECIFICATION MATERIALS—Rinshed-Mason Co. Catalog. A recently revised catalog lists government specification materials manufactured by this company. These include lacquers, varnish, enamels, thinner, antimisting compounds and wood sealer. Each material is listed opposite the government specification number.

(34) CENTRALIZED LUBRICATION SYSTEMS—The Farval Corp. Booklet, 8 pp. Illustrates and discusses centralized lubrication systems for industrial equipment. Actual case histories are presented to show cost and efficiency advantages of the systems.

(35) INDUSTRIAL ADHESIVE TAPE—Industrial Tape Dept. of Bauer & Black. Booklet, 20 pp. Pressure sensitive tapes are discussed and described in this booklet. The advantages of the various backing materials and different adhesive masses are presented. Twelve industrial taping problems are fully covered and solutions offered. An additional feature is a gatefold describing and illustrating by sketches the processes of solvent spreading and calendering.

(36) TESTING INSTRUMENTS — Scott Testers, Inc. Catalog No. 50, 66 pp. Covers testing instruments for all types of materials, with particular emphasis on the plastic and rubber fields. Included are instruments for testing tensile strength, abrasion, adhesive strength, state of cure, viscosity, flex life and other properties. Included also are tables of pertinent engineering information.

(37) DIE CASTINGS — The Hoover Co. Bulletin, 9 pp. This illustrated booklet discusses production, design and advantages of die castings. Rules for designing good die castings and a table of chemical and physical specifications are included.

(38) WELDING STAINLESS—Electrode Div. of the McKay Co. Handbook, 48 pp. Describes in detail all phases of stainless steel arc welding. Technical information includes metallurgical background, specific uses of alloying elements, AISI analyses, color guide and tensile data of the various groups of stainless steels. Also discussed are the uses and specifications of each type electrode and electrode coating.

(39) PRESSURE TERMINALS—Thomas & Betts Co. Sta-Kon Bulletin No. 61, 40 pp. Pressure terminals and connectors for every type of application on all wire sizes from No. 26 through 250 MCM are listed in convenient, easy-to-find form in this bulletin. Included is a section giving a complete listing of Armed Forces procurement numbers for simplification of the selection and procurement of fittings for aircraft and naval wiring and for ground force equipment.

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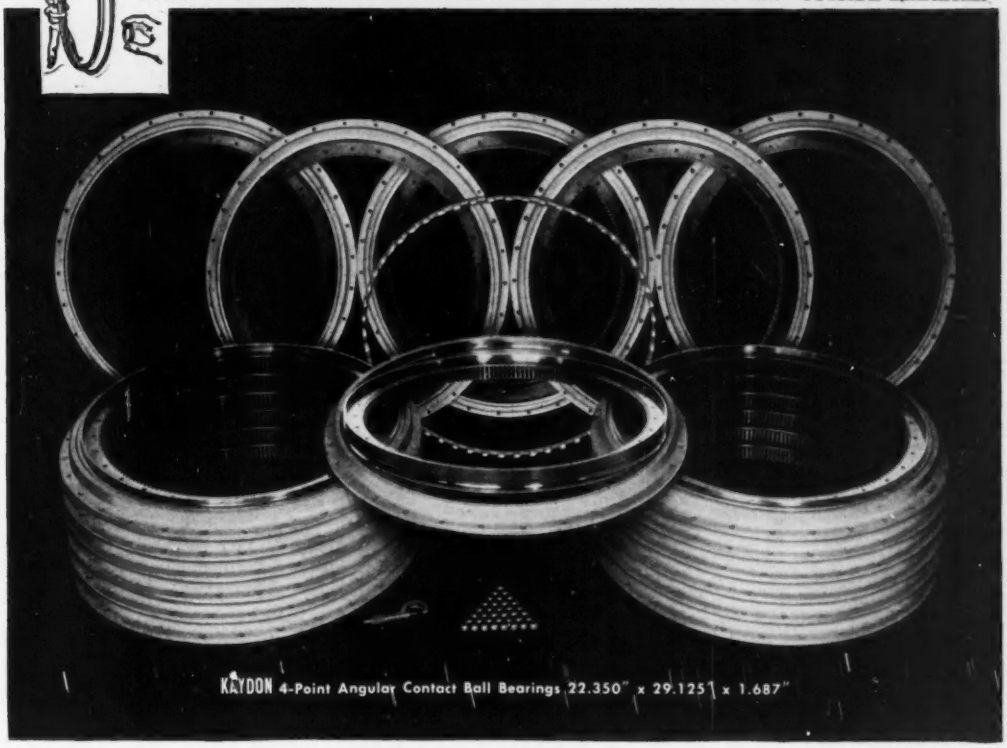

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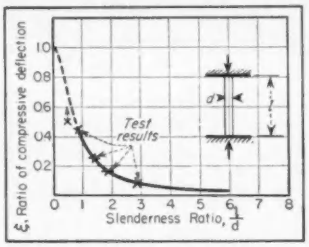

FIG. 3—The critical compressive relationship of a rubber rod of circular cross section which has ends hinged or constrained parallel.

cal number of turns, the coil will suddenly tilt or buckle as shown in Fig. 4. In such springs having a large number of coils, this critical number of turns does not depend on Young's modulus nor on the number of coils or the dimensions of the coil. The

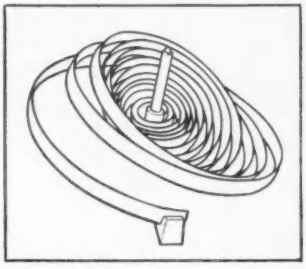

FIG. 4—Buckling of spiral springs is dependent on the cross section of the flat wire and the number of turns it is wound.

only determining factor is the ratio of cross sectional dimensions a and b. This relation is shown in Fig. 5.

When the ratio b/a is greater than 10 (most common), the influence of

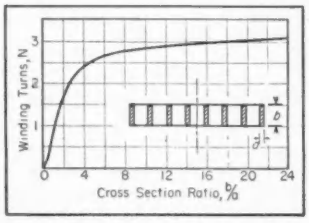

FIG. 5—Instability relationship of flat spiral spring. This curve is based on a spring with an infinite number of coils and closely agrees with test results.

this ratio almost disappears. Consequently for most spiral springs, the number of turns to cause buckling is approximately three.

One way to avoid this buckling is by placing the spring between parallel

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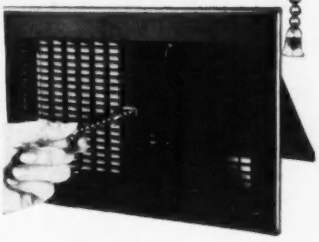

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disks; however, this introduces friction between the spring and the wall or between the coils themselves.

D-c Dynamic and Capacitor Braking

From "New Developments" by L. W. Herchenroeder, Industry Engineer, Westinghouse Electric Corporation. Paper presented at the 15th Annual Machine Tool Electrification Forum, sponsored by Westinghouse, April 10, 1951.

OBTAINING MORE REVERSALS PER MINUTE from squirrel cage motors on reversing duty cycles is an ever-present problem. High rotor resistance, reduced WK^2, of the motor and load, and special rotor construction for added heat dissipation are means frequently taken to obtain more reversals. In an attempt to find other means of increasing reversals, a study was made of the use of d-c dynamic and capacitor braking.

The rotor loss while accelerating a pure inertia load is equal to the mechanical stored energy in the rotating parts at synchronous speed. Also, the losses in the rotor while plugging to a stop are three times the mechanical stored energy of the rotating parts at synchronous speed. Thus in plug reversing, the major part of the rotor losses occurs while plugging from minus synchronous to zero speed.

With d-c dynamic braking, the total losses are equal to the mechanical stored energy in the rotating parts plus the loss in the stator due to the d-c current. The losses with capacitor braking cannot exceed the change in mechanical stored energy, since this is the only source of power. In addition, much of the loss may be dissipated in an external resistor. It was therefore felt that increased reversals could be obtained with the same temperature rise by using either capacitor braking or d-c dynamic braking and then plugging, instead of plugging over the complete reversal.

To test out the theory, a set-up was made in the laboratory using a standard NEMA design B, one-hp, 4-pole, 220-volt, 3-phase, 60-cycle, squirrel cage motor. Heat runs were made with various numbers of no-load reversals per minute, for reversing by plugging, d-c dynamic braking and capacitor braking. Tests were made on capacitor braking both with and without a loading resistor. The current used for d-c braking was 16.4 amp applied to two leads of the wye-connected motor. The capacitor braking circuit consisted of two 60-microfarad capacitors connected in open delta across the mo-

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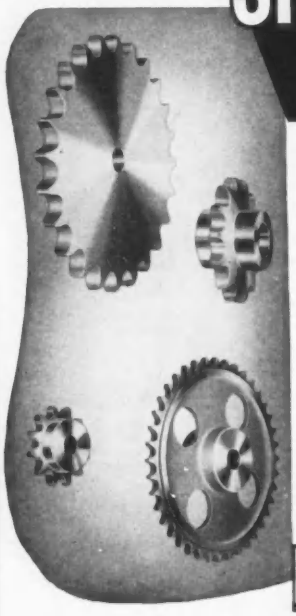

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tor terminals. For the capacitor braking with resistor loading, two 47-ohm loading resistors were connected across the capacitors.

The results of the test are plotted in Fig. 1. Capacitor braking with resistor loading gave the best results, permitting approximately 50 percent more reversals per minute with the same temperature rise in the range between 40 and 50 C rise.

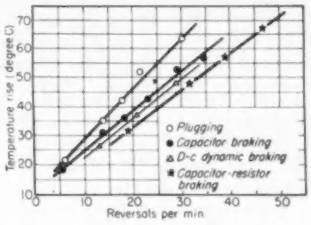

FIG. 2—Curves of temperature rise observed with various methods of obtaining reversal with one hp motor.

The added reversals per minute must be paid for by the added cost and space requirements of the capacitors, resistors, and control. The added control depends on the details of the reversing system. As a minimum, a contractor is required for the capacitors and resistors, and a timing relay is necessary for timing the braking period. In general, it appears that the added cost of capacitor braking can be justified when the reversals per minute or the load WK^2 are greater than can be handled by the use of a special motor with a high-resistance rotor. There will be cases, however, where personal preference for a standard motor or long delivery on a special motor will indicate the use of capacitor braking.

A New Method for Evaluating Fatigue Testing Data

From abstract and translation by A. Sonntag, Sonntag Scientific Corp., of paper by Dr. W. Spatu published in German "Metall", Sept. 1950.

TO REDUCE THE TIME for running fatigue tests to less than half that required when the conventional "Wohler" S. N. diagram is used, the reciprocal of the number of stress cycles, called destruction velocity, is plotted against the stress at failure.

With this new system, an indefinitely long life of a test specimen corresponds to a destruction velocity of zero; a short specimen life is desig-

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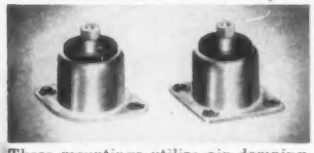

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- 509 — ALL-METL Barrymounts and mounting bases for unusual airborne applications.
- 605-606 — Miniaturized air-damped Barrymounts for use with airborne equipment.

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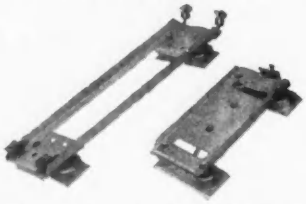
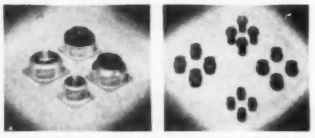


Standard bases built to meet government specifications can be furnished by Barry; special bases can be supplied in sizes and load ratings to fit customers' exact requirements, including miniaturized bases. See catalog 502 and data sheets 605 and 606.



Aircraft vibration isolators designed to meet Army, Navy, and CAA requirements are available in ¼-pound to 45-pound unit ratings; also miniature mounts to 0.1 lb. See catalogs 502 and 509 and bulletins 605-6.

Instrument mountings are furnished for electronic components, tiny, fractional-HP motors, record changers, dictating machines, and other lightweight apparatus. See catalogs 502 and 504.

Shock mountings for mobile, railroad, and shipboard service also give vibration isolation at frequencies above 2000 c.p.m.; useful for general sound isolation. See catalog 504.

Industrial mountings isolate vibration from fans, motor-generator sets, transformers, punch presses, and other heavy industrial equipment. Bulletin 607 tells how to cut maintenance costs with Barrymounts.

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nated by a destruction velocity of one. The limit toward infinite life, or endurance limit, now appears as a clear intercept with the stress axis instead of a horizontal asymptote that is often impossible to recognize.

To illustrate, Fig. 1 is a conventional S. N. diagram of an unusually

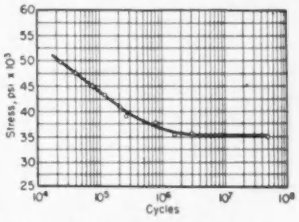


FIG. 1—SN curve for steel K20.

homogeneous steel. The logarithmical curve exhibits a well defined asymptote when ten test points are plotted.

The corresponding reciprocal values are used in Fig. 2 by assigning to the load cycle number 10^4 a destruction velocity of one. The upper curve shows

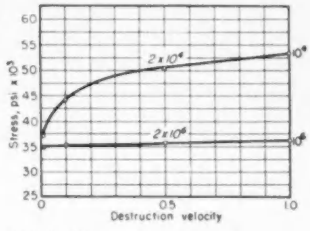


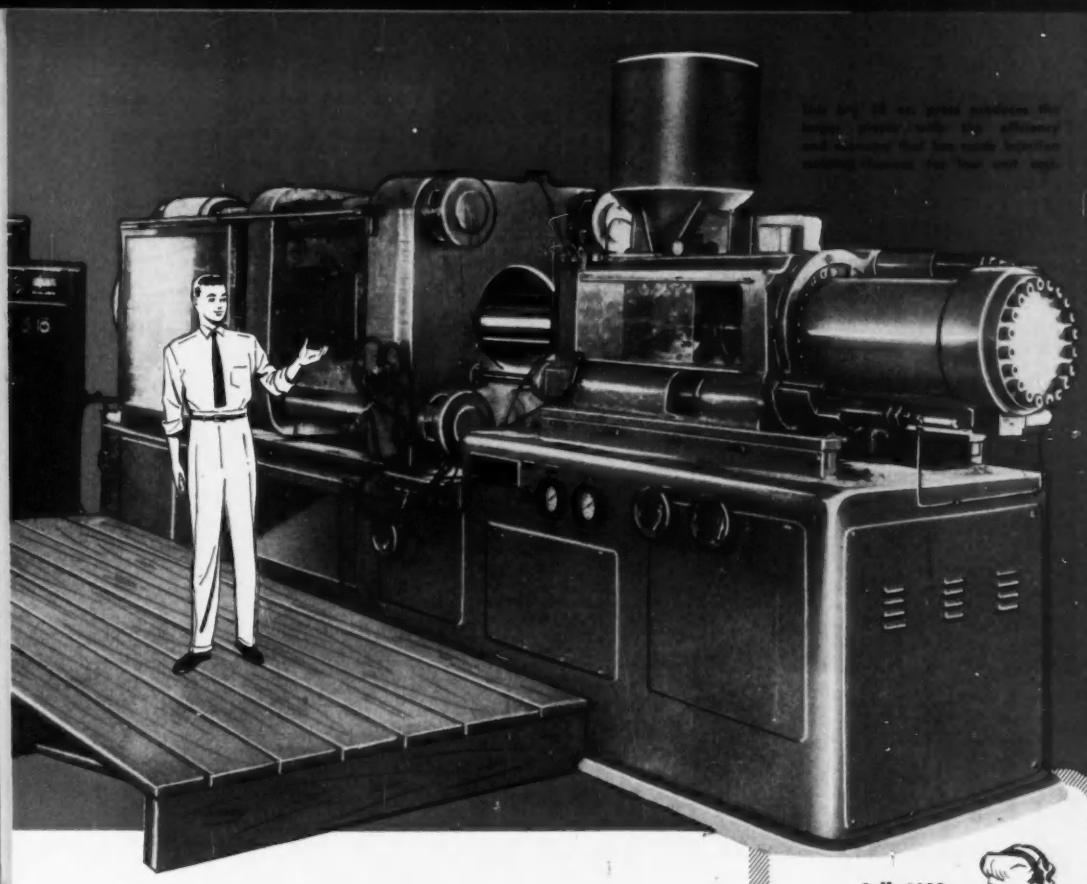
FIG. 2—SN curve transformed.

the result of this transformation. Note that 2×10^4 transforms to the reciprocal of two or a destruction velocity of one-half. However, no simple law becomes evident from this curve, the starting point being too low a number. A second transformation is therefore begun, starting with 10^6 as a destruction velocity of one. This results in a straight line (the lower curve of Fig. 2) which has a positive intersection with the ordinate axis.

Fig. 3 shows S. N. curves of four lead alloys. In contrast to the steel of Fig. 1, the asymptotes in this case are not clearly defined even at 10_8 cycles. Using the destruction velocity technique, however, and 10^7 cycles as unit velocity, the curves, Fig. 4, indicate clear intersections.

The four aluminum alloys of Fig. 5 have even less of a tendency toward a horizontal course, although the tests were continued to a billion cycles.

In transforming these curves, a load cycle of 10^6 is selected for a destruction velocity of one. In contrast to



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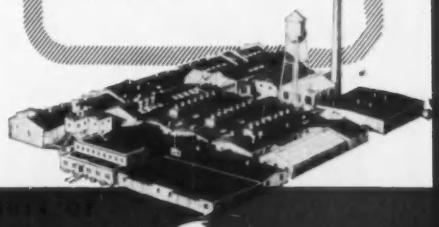

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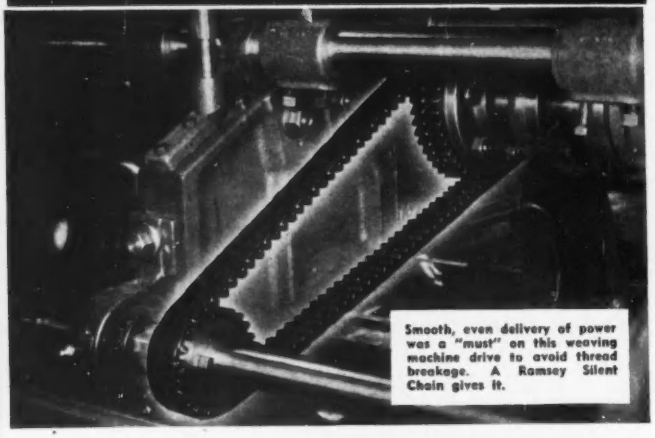

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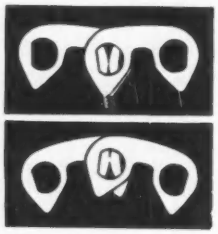

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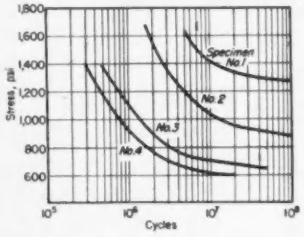


FIG. 3—SN curve for lead alloys.

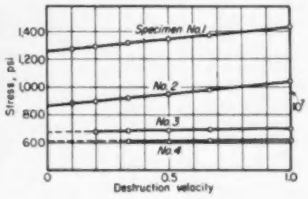


FIG. 4—SN curve transformed.

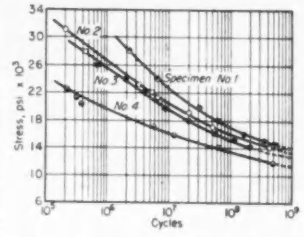


FIG. 5—SN curve for aluminum alloys.

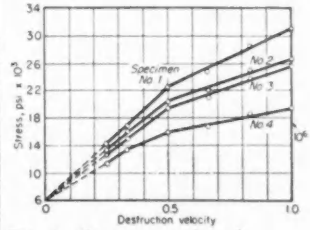
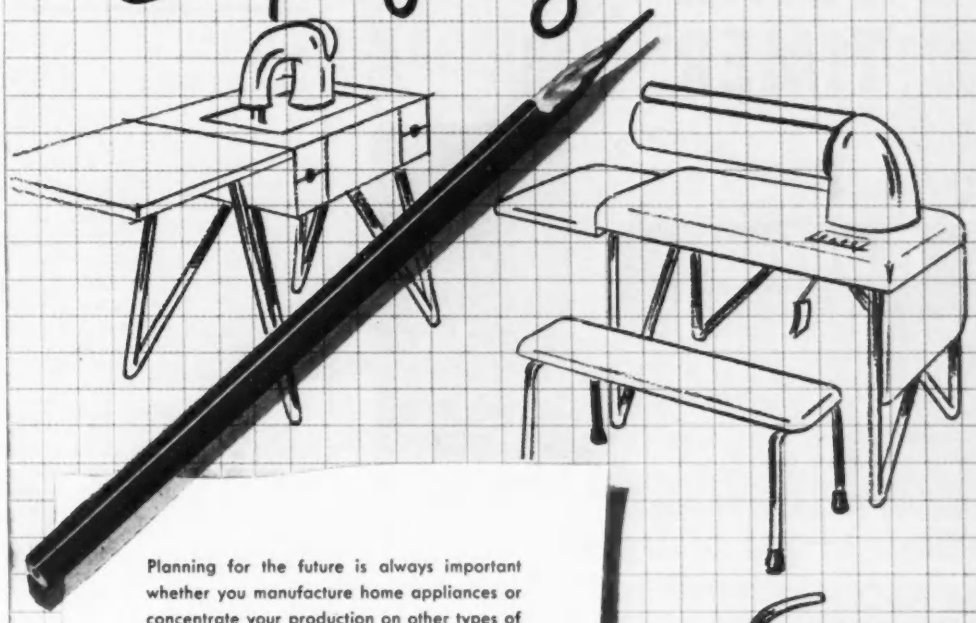


FIG. 6—SN curve transformed.

the two previous examples, this transformation is carried out directly for logarithmic plotting. The load cycle numbers of 10^6, 10^7, 10^8 . . . correspond to the values of 10^1, 10^2, 10^3, . . . and the resulting lengths of 1, 2, 3, . . . of the logarithmic scale are transformed directly. In Fig. 6 there accordingly appears the reciprocal value of 10^7 as half, that of 10^8 as one-third. . . .

Each curve of Fig. 5 transforms into a line consisting of two straight branches with different slopes. If the extrapolations indicated by the dotted lines are justifiable, all four alloys intersect the ordinate at a common point.

Shape of things to come...



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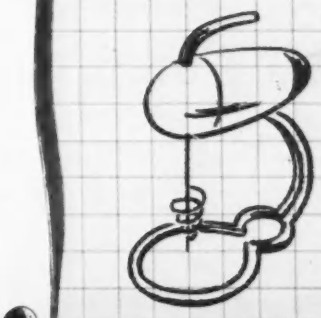

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OUR READERS SAY

Energy Losses in Hydraulic Systems

To the Editor:

I have read the final version of my article in the April issue of PRODUCT ENGINEERING. I find the arrangement of the material quite satisfactory, and I have received many favorable comments as well as requests for reprints. While reading the article I noticed several errors which I feel should be corrected before reprints are issued.

The equation for the loss in head should read:

$$H = \frac{1}{2g}\sum \epsilon_n V^2_n = 0.01553 \sum \epsilon_n V^2_n \qquad (1)$$

In Fig. 3 and Fig. 5, the curves for the coefficient of friction f for laminar flow are incorrect. It appears that by shifting the blue curve slightly, this error can be corrected. For your information the accompanying table gives values to properly orient this curve.

Laminar Flow Curve Fig. 3, page 147

Reynolds number R	Flow Ratio G/D
600	100
900	70
1,300	50
2,000	32

Turbulent Flow Curve

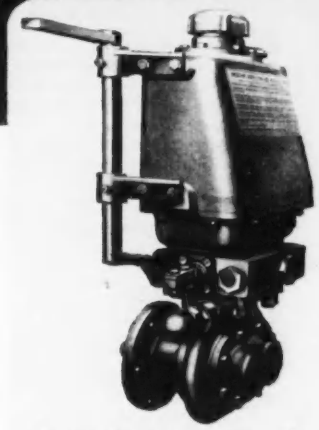
1,100	60
2,000	48
3,800	40
14,000	29

Laminar Flow Curve Fig. 5, page 149

Reynolds number R	Flow Ratio G/D
100	130
160	80
300	43
750	17
1,000	13

In the picture for divided flow,

LaPLANT-CHOATE *HYDRAULIC UNITS* make the Gradall do things ONE MACHINE never did before



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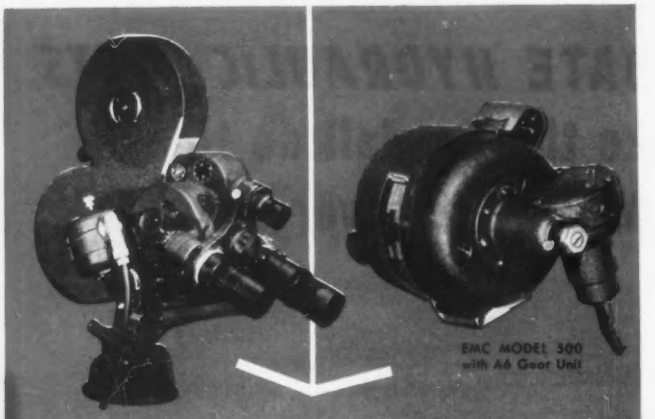

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DIVISIONS: EMC ELECTRIC MOTOR CORP. CYCLOHM MOTOR CORP.

Table I, item (D), page 150, the location of the upstream pressure tap should be inserted into the inner table as shown in Fig. 9. In the same table the square root sign in Eq. (13C) is not shown clearly. It should read:

$$\text{when, } \frac{\sqrt{(\Sigma D^2_n)}}{D} \gtrless 0.3$$

In Fig. 8 the loss in head in orifice flow is given as: Actual loss in head

$$H_1 = \text{chart } H \times \frac{\epsilon_o}{C_2}.$$

Unfortunately there is no numerical value for the coefficient of energy loss ϵ_o for orifices. This coefficient is a function of the coefficient of velocity and is expressed as:

$$\epsilon_o = \frac{1}{C_v^2} - 1$$

I hope that these minor errors be corrected in the reprinted article.

—NILS M. SVERDRUP
Monrovia, Calif.

Ed—We regret that these errors happened and hope that the incorrect plus sign in Eq (1) is so obvious so as not to be overlooked by those using it. The curves in Figs. 3 and 5 were misplaced slightly due to the misregistering in the printing process and were beyond our control. Your tabulated data and other corrections should be most useful in correcting these errors.

Pro and Con

To the Editor:

I would like to congratulate you on the May 1951 special issue of PRODUCT ENGINEERING. This is a magnificent job.

I have so many technical magazines to read that I customarily pick out certain articles from the index and read only those. However, I am determined to read this entire issue of PRODUCT ENGINEERING even though a great deal of it is not connected with the specialized field covered by my own company.

Since you have attempted, and I think with extraordinary success, to cover a very wide range of technology you will undoubtedly receive many letters from people who will point out that you have not completely covered some particular field. Such coverage is, of course, impossible within any reasonable space limitations and would take several years to prepare, by which time your information would already be out of date.

However, I must point out that in the section on "Semiconductors" page 132,3, you did slight a field of appli-

POWDER METALLURGY

PARTS EFFECT OPERATING SAVINGS

Cost-conscious users of production machinery are becoming increasingly aware of the over-all savings made possible in the operation of machines equipped with "COMPO" and "POWDIRON" bearings and parts. Maintenance expenses are reduced, since in many instances "COMPO" and POWDIRON" need no re-lubrication during the life of the equipment. When more severe service conditions do require re-oiling, the job is extremely simple—it is only necessary to bring oil into contact with the part. Even this simple attention is required only at infrequent intervals.

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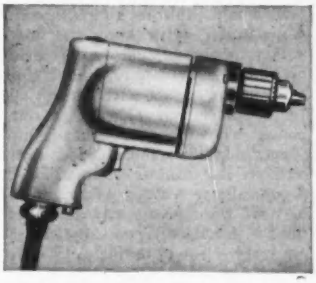

Electric drills equipped with "COMPO" bearings run smoothly and quietly, with minimum maintenance requirements

HOUSEHOLD AND BUSINESS APPLICATIONS

While the average user of household appliances or business machines is less aware of operating costs than the industrial executive, the long life and simple maintenance of "COMPO" and "POWDIRON" are important selling advantages in these types of products too.

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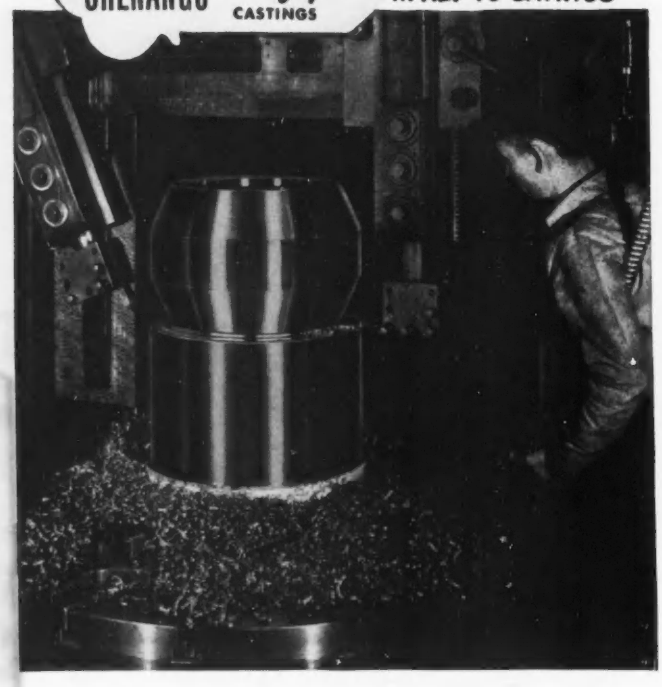

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cation which has grown greatly during the last ten years. I refer to the use of metallic rectifiers for electroplating. Some millions of amperes of metallic rectifier electroplating units have been installed during the past ten years. Since nearly all of the present manufacturers of electroplating rectifier units use the selenium type, and we introduced this type over ten years ago, we naturally feel like pioneers. Apart from this failure to mention electroplating rectifier units, we think you have succeeded in compressing a good deal of accurate information in the brief section devoted to "Metallic Rectifiers".

It is interesting to note that Mr. Pigott, in his opening review article, indicates that he is aware of the change in the electroplating field since he says "the oxide rectifier has changed the field of d-c current production, notably electroplating". Unfortunately, he used the term "oxide rectifier" rather than "metallic rectifier".

The only three metallic rectifiers used widely in the production of large quantities of d-c are the magnesium-copper sulphide, the copper oxide and the selenium. Only the second of these has an oxide in one of the two surfaces required to form a metallic rectifier. So far as we know, the magnesium-copper sulphide type is made by only one company, the copper oxide by two and the selenium by 12 or 13 manufacturers. The other companies who make the magnesium-copper sulphide and the copper oxide rectifiers also make selenium units. It is generally agreed that selenium rectifiers are *the* type for power applications. Incidentally, we ourselves do not make selenium rectifiers. We use them in our low-voltage, high-current rectifier units.

Again thanks for a remarkable issue.

—L. W. REINKEN
Green Electric Co., Inc.

To the Editor:

I was very much surprised about the editorial note that ran on pages 300 and 302 in your May number concerning the inquiry for leads for additional information on oil seals and sealing devices for rotating shafts.

I have been a reader of PRODUCT ENGINEERING for many years and I have often seen the advertisements of the Garlock Packing Company. I scanned through the list of companies suggested by the editor for more information on seals and was very much surprised to note that the name of the Garlock Packing Company, with which company I deal was omitted.

For the information of Mr. Charles

"Gravy ON YOUR HAIR?"

Just because gravy goes swell over noodles, he shouldn't assume it's good on hair, too!

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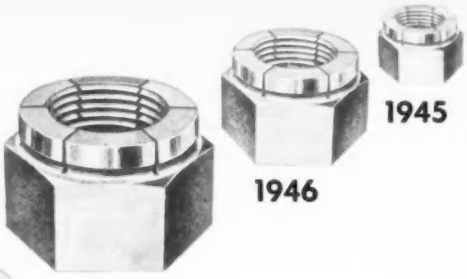

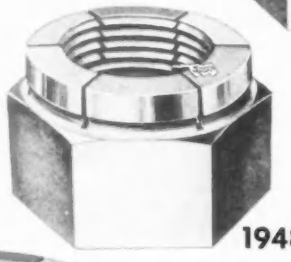

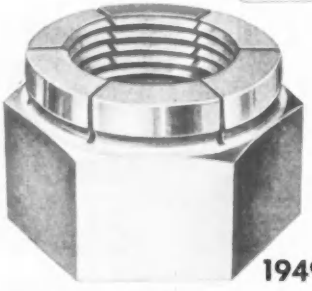

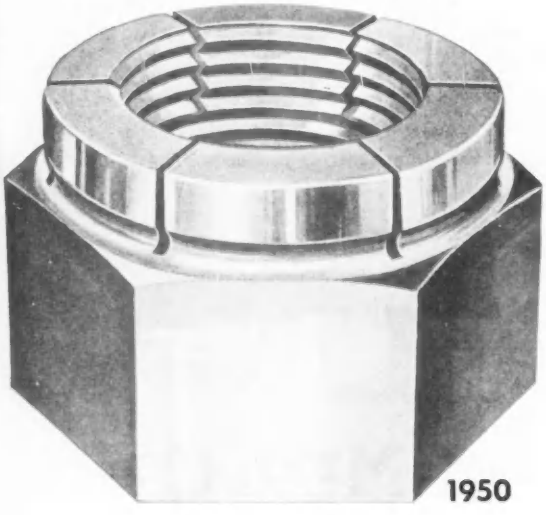

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C. Mangold, who made the inquiry, the Garlock Packing Company manufacturers not only oil seals, but also mechanical seals for rotating shafts, gaskets and all kinds of mechanical packings containing rubber, asbestos, metals, leather, flax and other materials. They also manufacture rubber transmission belting, industrial brake lining, and rubber expansion joints.

In view of the wide range of products offered by the Garlock Packing Company and in which your reader, Charles C. Mangold was obviously interested, I was naturally surprised that you did not mention that company.

—GEORGE C. NEUTON
Cleveland, Ohio

Ed—Our face is red. One would conclude that Mr. Neuton reads the advertising pages of PRODUCT ENGINEERING better than do the editors. We certainly committed an inexcusable error in omitting the name of the Garlock Packing Company as one of the manufacturers of rotating seals and oil seals of various types.

To the Editor:

We read with great interest the special editorial section of your May issue. It is really remarkable and a highly interesting piece of editorial work.

We have already ordered twenty-five copies of the reprint and are placing an additional order for fifty copies.

—W. KANDERS
Hydropress, Inc.

Safety in Springs

To the Editor:

The article by Carl Thumin and Hubert Riester, which appeared in the March 1951 issue of PRODUCT ENGINEERING, was of extreme interest. This article takes as a basis, the maximum allowable stress and then introduces corrections for fatigue life. Correction factors *C* given in Table VI are probably derived from spring material tests in laboratories in the time periods necessary to produce a definite number of cycles before failure.

There are many sorts of springs: Some working irregularly such as springs for safety valves and electric switches. For these springs, there are no reasons to use tabular values of factor *C* for applications steam or gas engine valve springs.

From this it appears important to establish values of safety factors according to the duty and service required of the springs. Considering the basic allowable stress given in the

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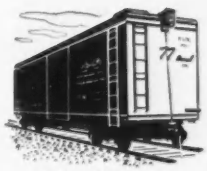

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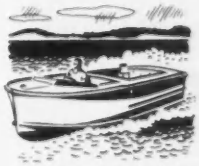

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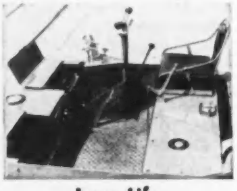

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spring selection Charts *A* and *B*, the safety factor values range from 1.74 to 2.06 for music wire and from 2.01 to 2.4 for carbon, oil-tempered spring steel. It is my opinion that a minimum value of a safety factor would be 2.5. For a factor of 1.74 for a spring with $d=0.2$ in. is not allowable under dead loads, such as for controlling hand levers.

The recommended procedure for determining number of active coils and the spring height, I found complicated since it requires some modification of the spring data specified. The number of inactive end coils e for compression springs is established, neglecting its dependence on the number of active coils N. Spring design practice establishes that for springs with squared, ground ends, the following relationship holds:

N	e
under 5	1.5
5 to 10	2.0
above 10	2.5

Using these data, an accurate formula for estimating initial height of spring under the initial load P_1 is:

$$H_1 = (N + e - 0.5)\,d + \frac{1.03\,(P_2 - P_1)}{P_2 - P_1}\,K$$

where P_2 is the final load and K is the deflection between P_1 and P_2.

—VICTOR TATARINOV
Pilsen, Czechoslavakia

The Information's Right, But the Name's Wrong

To the Editor:

Thank you for your letter of March 21 enclosing the story on splined connections.

The credit should have been "Gleason Works," rather than "Gleason Gear Works" which is incorrect.

Otherwise, we are pleased with the description and data given on Curvic couplings.

We feel that the two page story on splined connections will prove helpful to your readers and that the job was well done. —D. N. CURTIS
Gear Engineering Department

Our Mistake

To the Editor:

We would like to compliment you on the very fine article by Mr. Francis on Reinforced Plastics in the February issue. It contains data which will be of considerable value to our

Sales Engineers and if possible we would like to obtain one dozen reprints of this article. Incidentally, I do not find the curve referred to in the second paragraph, second column, page 88. Was this omitted?

—E. M. WOODRUFF
Auburn Button Works

Ed—Under separate cover, we are forwarding to you 12 copies of the article by Richard J. Francis on Reinforced Plastics.

Unfortunately, you have discovered the one serious mistake in this article and that is the omission of the curve referred to in the second paragraph, second column on page 88. This curve was omitted because of our space limitations and we simply missed the reference to it in the text.

Singing Praise, But . . .

To the Editor:

I am pleased to mention what a valuable reference number your May issue is. It's wonderful and I'm glad to be in it.

Although you have made a pleasing presentation of my nomograph on cones and pyramids on page 209, there is a typographic error. The final volume, V should be 108 not 10.8 cu inch.

In my comments on page 286 of the same issue, referring to paragraph two, 684 ft should be 784; in paragraph six (line 6) the word *lines* should be *times*, or 13 x 80; finally (line 10) the number of mean turns is 0.738 ft and not 738. —CARL P. NACHOD
Nachod & U. S. Signal Co., Inc.

Ed—We regret that these errors occurred and feel sure that they were sufficiently evident to those interested in this subject to be corrected.

Radial Disk Cams

To the Editor:

I read the article "Radial Disk Cam Design Charts for Maximum Pressure Angle" by A. Lengyel and A. H. Church in March issue of PRODUCT ENGINEERING with considerable interest. The pressure angle in cam design is many times of great importance and the use of such charts simplifies calculations and aids one's judgment.

Concerning Fig. 3, I would like to add that there are times when $\frac{L}{R} > 1$, in which case, the general formula given in Fig. 3 no longer holds. For $\frac{L}{R} > 1$ Maximum pressure angle τ_m

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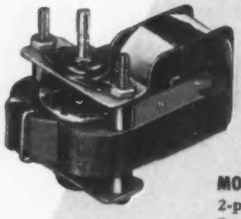

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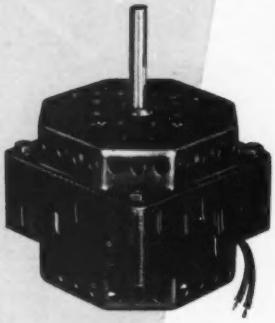

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$= \text{arc tan } \frac{1}{\beta}\sqrt{\frac{L}{R}}$. Cam angle at α_m, $\theta = \beta\sqrt{\frac{R}{L}}$.

I believe Fig. 5 is in error or is a misnomer. The equation of cycloidal motion is:

$$\rho = R + \frac{L}{\pi}\left[\frac{\pi\theta}{\beta} - \frac{1}{2}\sin\frac{2\pi\theta}{\beta}\right]$$

using notation given on Fig. 1.

At $\theta = 0$ the pressure angle $\frac{d\rho}{\rho\, d\theta} =$ 0 and is not a maximum, as stated in Fig. 5. Also, the value of α_m in Fig. 5 can quite simply be shown to be incorrect by comparison with α_m given in Fig. 4, since for the same $\frac{L}{R}$ the constant velocity curve would have a smaller, not larger, pressure angle.

—WAYNE A. RING

Ed—You're right, of course, Church and Lengyel have gotten their slide rules out and have prepared a corrected chart which you'll find next month.

Good Excuse

To the Editor:

Although my letter is late, I would like you to consider it because the December number of PRODUCT ENGINEERING arrived at my office later than usual. Therefore, will you please forward my letter to the advertisers so that I can obtain my booklets.

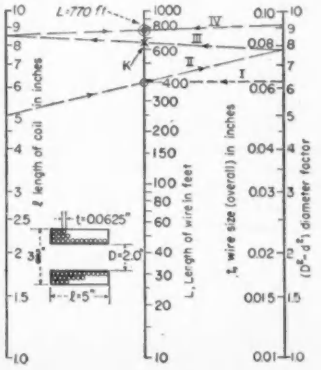
I am a great lover of McGraw-Hill books and I have all kinds of McGraw-Hill Electrical books.

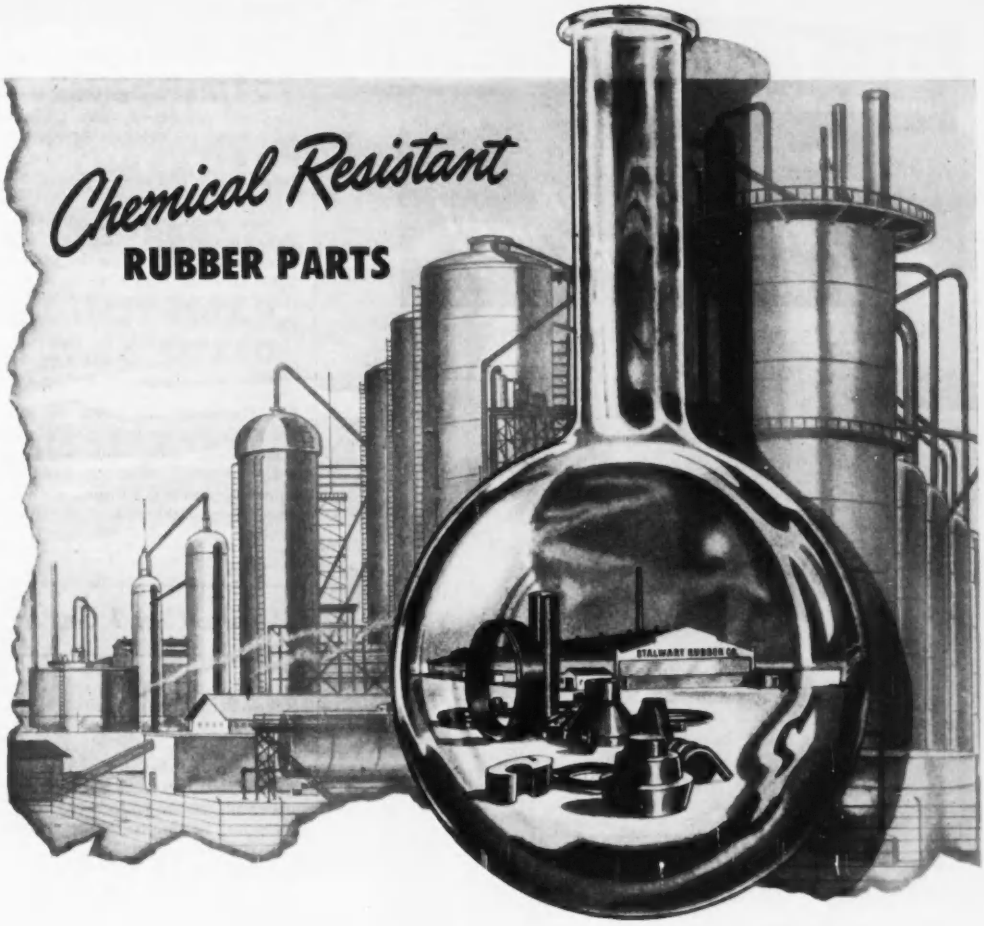
—BARBADOS
West Indies

Here's Another Answer!

To the Editor:

In reply to Mr. Tatarinov's problem (PRODUCT ENGINEERING, March, p





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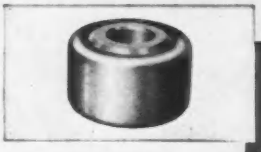

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224), here is a chart which may interest him and other engineers. This chart is for finding the length of coil wire and consists of three graduated scales which are based on the equation:

$$\text{Length of wire, } L = \frac{l\,(D^2 - d^2)}{15.3\,f^2}$$

This chart and the symbols are shown in the figure. Illustrated is the problem for finding the length of a 1,000-turn coil with 1/16-in. wire an ID of 2 in. and a length of 5 in. The answer is shown to be 770 ft. This chart is most accurate for finer wires.

—CARL P. NACHOD, V.P.
Nachod and U. S. Signal Co.

Ed—For those who might be interested, this chart can be amplified. The scales are parallel and equidistant apart. Plotted on a log basis, the outer scales extend 10 units while the center scale is 100 units. The constant K equals 1/15.3 or 0.655.

Where Can I Get It?

Pneumatic Components

To the Editor:

I understand that part of your service to subscribers is to furnish information on specific subjects.

I would be glad to receive any data that you can supply on pneumatic chucks and fixtures, and their control valves.

—W. F. A. MOONEY
Raleigh Eng. Co. Pty. Ltd.
Victoria, Australia

Ed—Any one of the following manufacturers should be able to furnish the information you need: Logansport Machine Co., Logansport, Ind.; Gisholt Machine Co., Madison 10, Wis.; and Skinner Chuck Co., New Britain, Conn.

Bound Design Work Sheets

To the Editor:

Do you publish a reference book consisting of graphs and curves compiled from the monthly magazine of PRODUCT ENGINEERING? If you do, please send information on the book, that is price, issues of PRODUCT ENGINEERING covered etc.

—GREG TURNER, ENGINEER
Manufacturers Battery Co.

Ed—PRODUCT ENGINEERING has available as a subscription bonus booklet that is published every two years called

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"Design Work Sheets". This is a collection of our Reference Book Sheet material and the two-page drawing description articles that we carry each month.

Unfortunately, the only copy that you would be able to obtain would be one currently in print, the 10th series and naturally, that does not include material that was used in previous years.

The only other suggestion that I might make is that you see if the McGraw-Hill Book Company still has in stock a copy of the Mechanical Designers Handbook by Nordenholt, Kerr and Sasso. Frankly, this book went out of print some time ago, but it is the only one available at the moment that contains all such information. We have another book that is currently in the works but its publication is still at least 9 months away.

If you would like to obtain a copy of the current edition of "Design Work Sheets", I would suggest that you contact Mr Lawrence Crosby, Circulation Department, who I believe will secure a copy for you, the price of which is one dollar.

One For the Author

To the Editor:

We are interested in the hopper feeds described by William Schwartz in the October issue of PRODUCT ENGINEERING and would like some further information.

In regard to the vibratory bowl feeder, we would like to know who is the manufacturer of the standard vibrator unit. We also would like to know what causes the parts to climb the spiral track.

—PAUL G. SPAULDING
Paul G. Spaulding and Associates

Ed—Further detailed information about the hopper feeds can be obtained from the author, Mr. William Schwartz, Concourse Plaza Hotel, New York 56, N. Y.

Printed Circuit Data

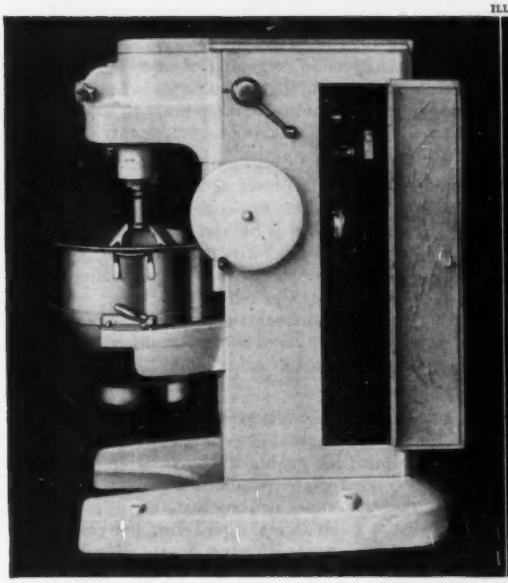
To the Editor:

It has been suggested to us that you may have information on printed circuits, or could put us in touch with companies who would have these data.

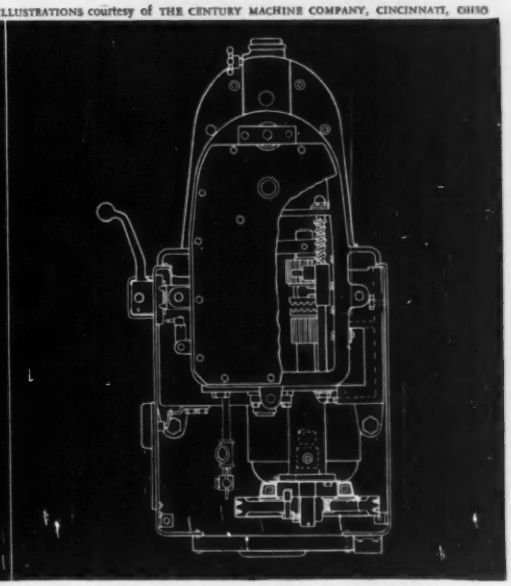
As you know, printed circuits are replacing wired circuits in many applications such as small radios and intercommunication equipment. Conductive material forming a required circuit pattern is printed on the dielectric and various components are attached

How A Warner "ICB" Unit Simplifies Control on a *Century* Vertical Dough Mixer

ILLUSTRATIONS courtesy of THE CENTURY MACHINE COMPANY, CINCINNATI, OHIO



Side view of vertical dough mixer. Note position of Warner "ICB" Electric Brake Unit next to drive sheave (top right) and single control lever (top center).



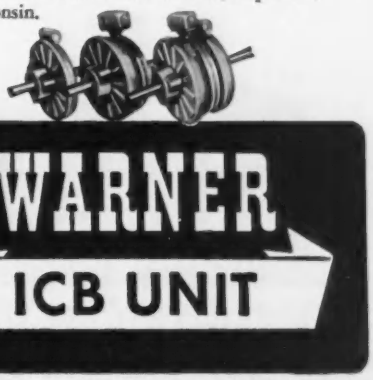
Top view drawing of dough mixer showing Warner "ICB" Brake Unit mounted on drive shaft next to sheave.

What Century says About the WARNER "ICB" Unit

Using a Warner "ICB" Unit on the Century Vertical Dough Mixer gives extremely simple quick-acting control. It enables us to make a single lever do the complete job of starting, stopping and speed selection.

It also enables the use of positive tooth clutches without clashing when changing speeds. The operator has complete shifting control because the single lever simultaneously de-energizes the motor, energizes the Warner "ICB" Brake and disengages the clutch. Moving the lever to the desired speed position mechanically places the clutch teeth in position to engage. Release of lever simultaneously releases the Warner "ICB" Brake, energizes the motor and engages the clutch.

Warner "ICB" Units are electrically-powered, low-wattage clutches and brakes. They can be operated singly or in combination—automatically or by push-button control. Because they are electric—they give lightning-fast response. Because they are compact and simple, they provide easy installation and long-term dependable operation. They're a new answer to a wide variety of old machine design and operation problems. For further information on how Warner "ICB" Units may help you — write today to the WARNER ELECTRIC BRAKE & CLUTCH CO., Dept. PE, Beloit, Wisconsin.



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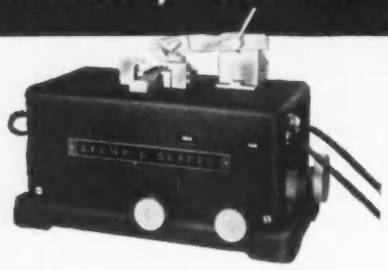

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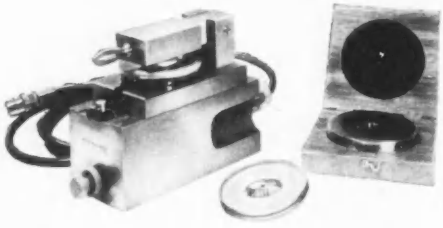
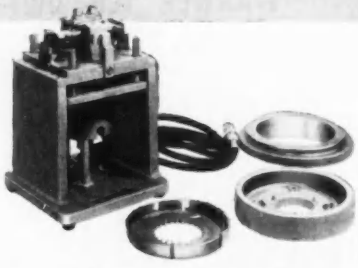


Special gaging fixture, custom-made by Brown & Sharpe, permits gaging of meter valve plate flatness to .00001", when used with Brown & Sharpe Amplifier.



Custom-made fixture, employing Brown & Sharpe Gage Head Cartridge and one Amplifier, simultaneously measures major and minor I.D.'s of tapered bores and indicates accuracy of internal angle.

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thereon, the printed impression taking the place of wires.

Any assistance you can give us in this respect will be very much appreciated. —F. C. C. WILKES, JR.
The John Wilkes Press, Ltd.
Toronto, Canada

Ed—There are many concerns in this country who have developed pattern circuits for electronic equipment using printing or stamping techniques. The Research Laboratories of Sylvania Electric Products, Bayside, New York; the Hallicrafters Co.; the Zenith Radio Corporation, Chicago, and many others are working along these lines.

For a basic and thorough analysis of what's going on in the field, we suggest a letter to Mr. Gil Reed, Manager of the Electronics Section, National Bureau of Standards, Washington, D. C. Much of his work is, of course, of a classified nature, but we are sure that Mr. Reed can give specific suggestions as to technical articles on this subject.

Overwhelming Response

To the Editor:

The Hughes Research and Development Library would appreciate receiving two reprint copies of each of the following articles which appeared in the November, 1950 issue of PRODUCT ENGINEERING: "Engineering Design with Natural and Synthetic Rubbers" by Ellwood Riesing; "Fatigue Weakness of Surfaces" by J. O. Almen; "Telephone Type Relays—Coil Construction and Timing" by V. E. James; "Applying Shakers for Product Vibration Analysis" by Robert C. Lewis. —JOHN T. MILEK
Hughes Aircraft Co.

Ed—Enclosed you will find copies of the articles you requested, with the exception of "Fatigue Weaknesses of Surfaces." We regret to say that we do not have any copies available of the latter article, because of the large number of requests for reprints.

We suggest that possibly the General Motors Corp., of whose research staff the author of this article has long been a member, may have copies which can be made available to you. If you are interested in finding out if copies are available from General Motors, please write: Mr. Richardson, Technical Data Division, Research Laboratories, General Motors Corp., 485 West Milwaukee Ave., Detroit, Mich. Should you be interested in obtaining copies of Mr. Almen's more recent articles on various aspects of fatigue, our Reader Service Dept. has a supply.

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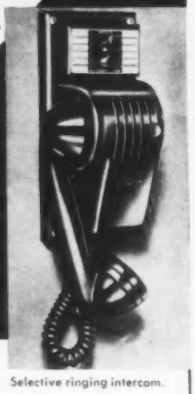

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Economics of Industrial Research

Proceedings of the first annual conference on Industrial Research in June 1950 at Columbia University, D. B. Hertz editor. 5½ x 8½ in., 261 pages. Published by King's Crown Press, 2960 Broadway, New York 27, N. Y. $4.50.

Industrial research activities are constantly assuming greater importance in our national economy. This work may be: surveying the market for new products, improving methods of production, development of improved statistical control for experimental work, or evaluating the direction of exploration activities. It may be conducted within the company, or by outside agencies or by using the facilities of a university. Regardless of who performs the specific task, there is the problem of organization, costs and direction which necessitates greater control.

Although industrial research is responsible, in a large part, for the ever-increasing standards of our material well-being, yet large segments of industry are still to be persuaded that the skills and training of researchers will justify the necessary financial outlay in business.

The discussions at this conference point the way to sources of capital to finance research work. In addition, methods are described how to organize and keep to a minimum the costs of such activities. The importance of agencies and universities for research work is delved into. The final chapter of 84 pages covers discussions of individuals at the clinic sessions

Impact Die Forging

Soft cover, 70 pages, 7 x 9 in. Published by Chambersburg Engineering Co., Chambersburg, Pa. $1.50.

To meet the need for basic information on the subject of Drop Forging, the Chambersburg Engineering Company, with the cooperation of the School of Engineering of Princeton University, has prepared a series of charts that form the main part of this booklet.

This material is organized primarily for the convenience of instructors in technical and engineering schools either to form the basis of their courses or to supplement such courses. The charts are grouped in five sections so

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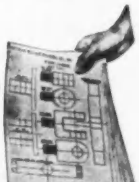

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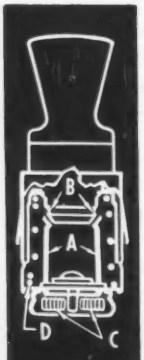

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The thermostatic bimetal is formed into a two-pronged latch (A). When the knob is pressed into the socket, the pronged latches catch on the flange at (B), thus holding the circuit closed between the contact in the socket and the coiled element (C). When the element reaches the correct glowing heat, the bimetal latch reacts, releasing its grip on the flange. Spring (D) breaks the contact with an audible *snap*. This mechanism completely eliminates the danger of burning out the element.

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that the instructor may use the course either in its entirety or may select one or more sections for special consideration.

The Charts are grouped logically into sections as follows:

Section 1—"Why a Drop Forging"—This section covers the reasons for producing a part by drop forging rather than by other fabricating processes. Also outlined are the characteristics of the principal metals used in drop forging.

Section 2—"The Drop Hammer"—This section deals with the machinery for producing a drop forging.

Section 3. "Design of a Drop Forging"—This is a series of charts and descriptive matter by means of which one may take any given designed part and by following the sequence of the charts, learn the basic rules to be followed in producing a satisfactory drop forging.

Section 4—"The Drop Forging Process"—This section discusses the sequence of steps taken in working the metal from bar stock to the final drop forging and teaches basic drop forging die design.

Section 5—"Drop Forging Manufacturing Tolerances"—This section gives the tolerances that should be allowed in designing a drop forged part.

Fluid Mechanics

VICTOR L. STREETER, *research professor in mechanics and director of fundamental fluids research, Illinois Institute of Technology. 366 pages, 6 x 9 in. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York 18, N. Y. $5.*

The general order of presentation of material in this textbook follows the traditional pattern. Statics are first considered, and are followed by an introduction into the concepts, basic definitions, and equations for fluid flow.

Adequate attention is given to the principles associated with the action of fluid jets, laminar flow, flow measurement, steady flow in closed conduits, flow in open channels, and flow around immersed bodies.

Of particular interest and value to mechanical engineers is the author's treatment of the broad fluid mechanics principles underlying turbomachinery, lubrication, jet propulsion, rockets, torque converters, pumps and blowers, and oil hydraulic systems.

The chapter on oil hydraulic systems deals with the production, transmission, control, and use of hydraulic power through the fluid medium of

oil. The essential features of the three basic types of rotary positive displacement pumps are described and the theory associated with their performance as pumps and motors are discussed. Included also in this chapter are topics such as hydraulic fluids, reservoirs, tubing, accumulators, intensifiers, control valves, and hydraulic circuits.

Objective-type problems and questions are given at the end of each chapter. In addition numerical problems are also included, ranging in difficulty from the very simple to those requiring analytical development by the reader. Many illustrative examples further aid the reader in his study of the various topics covered.

Treatise on Powder Metallurgy, Vol. II

CLAWS G. GOETZEL, *PhD, Vice-President and Director of Research, Sintercast Corp. of America, New York, N. Y., Adjunct Professor of Chemical Engineering, N. Y. University.* 910 *pages,* 6 x 9 *in. Published by Interscience Publishers, Inc., New York, N. Y.* $18.

Volume II of this series of three, follows the discussions of the technology of metal powders and their products which was included in the first volume with a very vigorous treatment of applied and physical powder metallurgy. The manufacture, production and properties of the important metals in this field are discussed in detail with excellent illustrations.

Information which was obtained from over 100 reports from Field Investigators covering Occupied Europe is incorporated with data obtained in this country. British and German experiences with powder production in the hard metal field are treated extensively as are the interesting methods of manufacturing iron powder that were developed in Germany during World War II.

Besides considering the practical aspects of powder metallurgy, this volume has many excellent theoretical analysis of the powders, processes, and products. An impartial summary of the various theories of bonding and sintering includes all outstanding contributions plus a number of less outstanding ones which may eventually rank with the others in importance. In presenting this historical development of the various theoretical concepts of sintering, the author indicates a preference for the more conservative theories. These, are based primarily on diffusion processes, sup-

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ported by the action of surface tension forces.

Volume III, which is not yet available, is intended to comprise a classified and annotated bibliography of both literature and patents in this field.

Mechanical Fastening Methods for Aluminum

F. F. DIETSCH, *Specifications Engineer. 136 pages, 6 x 9 in. Published by Reynolds Metals Co., 2500 South Third St., Louisville 1, Kentucky.*

This is the latest addition to the group of technical books published by Reynolds Metals Company. Here are 136 pages of information on the many different ways for mechanically joining aluminum parts, including the use of metal stitching, resin bonding and ingenious mechanically formed joints. Other joints are made with rivets, screw fasteners, nails, or pins . . . . . all are described in detail, their applications analyzed and advantages pointed out.

Unlike welding, brazing and soldering, which are limited to the production of metal-to-metal joints, mechanical fastening methods are suitable not only for joining aluminum to aluminum, but aluminum to wood, plastics, fabrics and other non-metallics. However, there has been little published information available on these important fabrication processes and it is to answer this need that this book has been written.

The book is divided into eight main sections. These are devoted to (1) standard rivets, (2) special rivets, (3) standard screw fasteners, (4) special screw fasteners, (5) nails and pins, (6) metal stitching, (7) mechanically formed joints and (8) resin bonding.

In addition to 95 pages of text, there are three indexes, including a condensed table of contents, an index of tabular matter, and an itemized cross index. Some 314 illustrations show how the various fastening systems work and present typical applications.

There are 17 tables of related data, including dimensions and number of pieces per pound for six different types of standard rivets, lengths of rivets for cone-point and button type driven heads, recommended hole sizes with shear and bearing areas for both hot and cold-driven rivets, and maximum loads for single rivet in shear.

Trade names of special screw fasteners and their makers are also listed, as well as nominal chemical compositions and typical mechanical properties of the wrought aluminum alloys.

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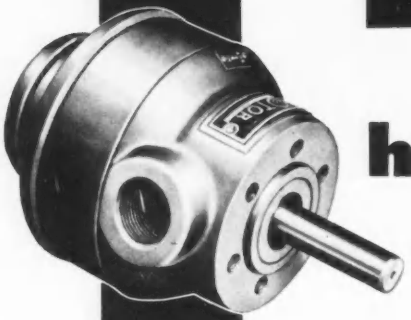

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Typical tensile and bearing properties of aluminum alloy plates and shapes are also included. Dimensions for standard aluminum spring lock washers are given. Another table lists recommended interference fits for cast iron and steel bushings in aluminum at room temperature.

An 18-page itemized cross index completes the book. It references all topics covered in the text, tables, and illustrations for easy spotting of any particular subject or trade-named item. It will be sent without charge to engineers, designers, production men and executives in the metalworking industry who request it on company letterhead.

Engineering and Western Civilization

JAMES KIP FINCH, *Renwick Professor of Civil Engineering and Dean Emeritus of the School of Engineering, Columbia University.* 397 *pages,* 6 x 9 *in. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York* 18, *N. Y.* $5.

Much of the material, secured as it was from original sources in various scattered and not too easily available publications, is of interest in revealing the remarkable evolution, through some fifty centuries or more, of one of the oldest of the practical arts. While important technical principles and a valuable perspective of professional progress can be drawn from such a detailed study of the sequence and development of engineering discoveries and inventions, the methods and practices of yesterday offer little more than curiosity-satisfying value to the engineer of today.

On the other hand, throughout these fifty or more centuries of its history, engineering has been a potent instrumentality in the rise of Western life. This story has more than merely professional interest. On its proper understanding and interpretation in the light of our present problems and needs, the future of Western life will to a major degree depend. For, while engineering in the past has aided in transforming man's dwelling place and also exercised a profound influence on the relationships of men, it has, within the past century or less, become a dominating force in shaping not only the lives of men but the destiny of nations.

Little attempt has been made to offer more than a very brief and sketchy outline of the history of engineering, although a selected bibliography is given which will provide suitable references for further study for those who

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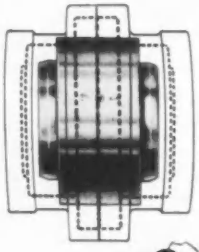

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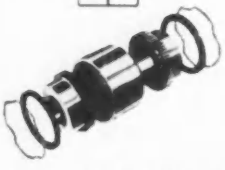

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desire to fill out some of the details of this story. Special attention has been given to an attempt to uncover some of the basic relationships of past engineering advances and economic and social changes. If continued engineering progress is an inescapable essential in our search for the good life for man, to our safety and stability as a nation, and to our power for peace in the world, then it is our responsibility not only to understand how to use technological advances to the optimum advantage but also how to provide those conditions which will foster and maintain such advances. It may be true that ill-considered and short-sighted economic or social legislation cannot prevent scientific research, but that it can so retard or restrict engineering progress as to result in technological stagnation and decay is, unfortunately, only too evident in the records of past civilizations.

Radio Engineering Handbook

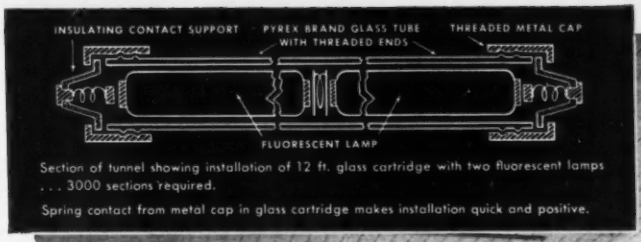
KEITH HENNEY, *Consulting Editor, Electronics Magazine. Fourth Edition, 1197 pages, 6 x 9 in. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York 18, N. Y. $10.*

In preparing new material and revising existing material for this Fourth Edition, the same guiding principles have been followed as in the First Edition in 1933. Throughout, the endeavor has been to create a comprehensive working manual of the radio science and to compile in a single volume concise information on each of the branches of radio engineering. In the years that have elapsed since the Third Edition, the war and all its technology have intervened. Much that existed in 1941 has been radically changed or has disappeared from the engineer's tool kits. Much that was only thought of—if at all—in that year is now standard practice. For example, the Third Edition does not mention wave guides. This volume has an entire chapter devoted to the subject.

Several chapters are totally new, for example, those on inductance and magnetic materials, wave propagation, electron tubes (much of which has never been published before), antennas, receiving systems, and radio aids to navigation. All other chapters have been throughly revised.

The first chapter in this edition, also new, represents a concise summation of the principles upon which the electrical communication art, radio particularly, is founded.

Much material from previous editions has been eliminated (the mathe-



Section of tunnel showing installation of 12 ft. glass cartridge with two fluorescent lamps . . . 3000 sections required.

Spring contact from metal cap in glass cartridge makes installation quick and positive.

So we built 12 foot PYREX cartridges . . . and helped solve a tunnel lighting problem

You can see for yourself that a continuous pipeline of light eliminates flickering shadows in the new Brooklyn Battery Tunnel . . . a great boon to traffic safety and driving comfort. But New York Tunnel Authority engineers had first to find a way to protect the light source from breakage by high pressure hoses and flapping tarpaulins—replacements had to be safely and quickly accomplished.

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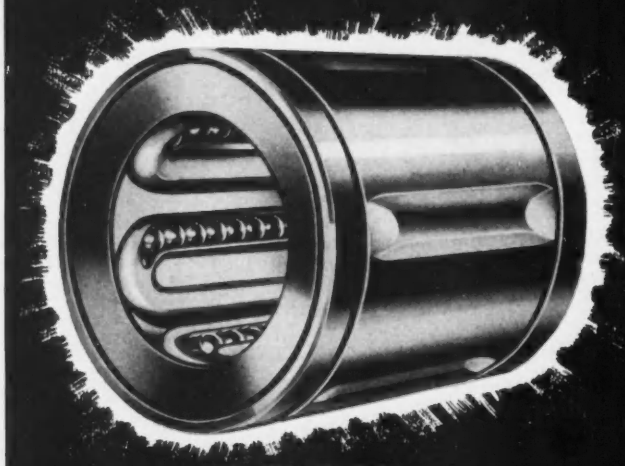

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matical and mechanical tables, for example) not only to provide space for recent techniques but also to present a book economical in volume, weight, and cost. Nevertheless, this Fourth Edition is about 80 percent larger than the Third Edition.

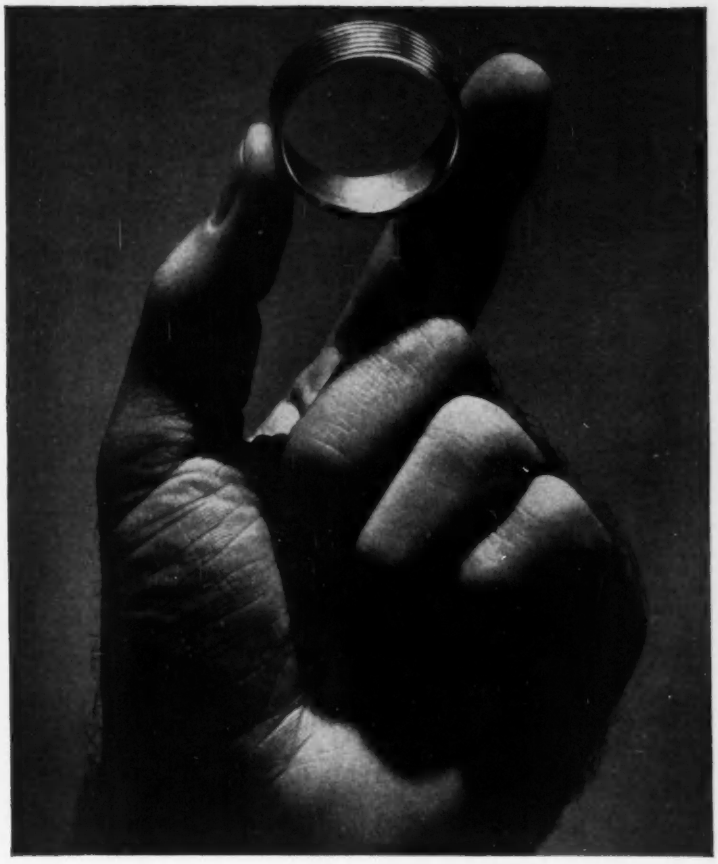
While there is much of what may be called fundamental background in this book, the emphasis has been on working practice rather than theory as a general concept of the purpose of a "handbook". The engineer will find in this book many man-hours of effort compiled in the form of tables and curves or converted into concise English by the engineers, physicists, and teachers who have aided the editor in preparing this new edition.

Elements of Television Systems

GEORGE E. ANNER, *Assistant Professor, Electrical Engineering, New York University.* 5½ x 8½ *in.,* 804 *pages. Published by Prentice-Hall, Inc.,* 70 *Fifth Ave., New York, N. Y.* $10.35.

Recent trends in the development of television systems for specialized industrial uses and for the transmission of images in full color have made classical methods obsolete for teaching the principles of those systems. These methods have concentrated on the television broadcasting system as standardized in the United States of America. It is believed that this limited point of view leads the student to misconceptions about transmission standards and, in some cases, to incorrect interpretations of design philosophy. For this reason the present work begins with a study of closed systems, those that rely upon cable connections between sending and receiving apparatus. In this manner those features of the commercial system that depend solely upon the use of radio waves as a carrier are eliminated, and the field of interest is restricted to the problems of converting an image to an electrical signal and of reversing that process.

In the second portion of the book the point of view is expanded to include the complications introduced by using a radio link in place of interconnecting cables. The last portion is concerned with methods of superimposing color-perception on a system which is inherently color blind. Since details of a new art change rapidly, an attempt is made to concentrate on the basic principles involved. Liberal use of footnote references to articles in the literature has been made so that the interested student may readily locate source material if he wishes to make further studies.



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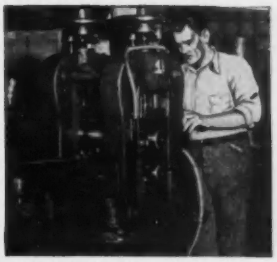

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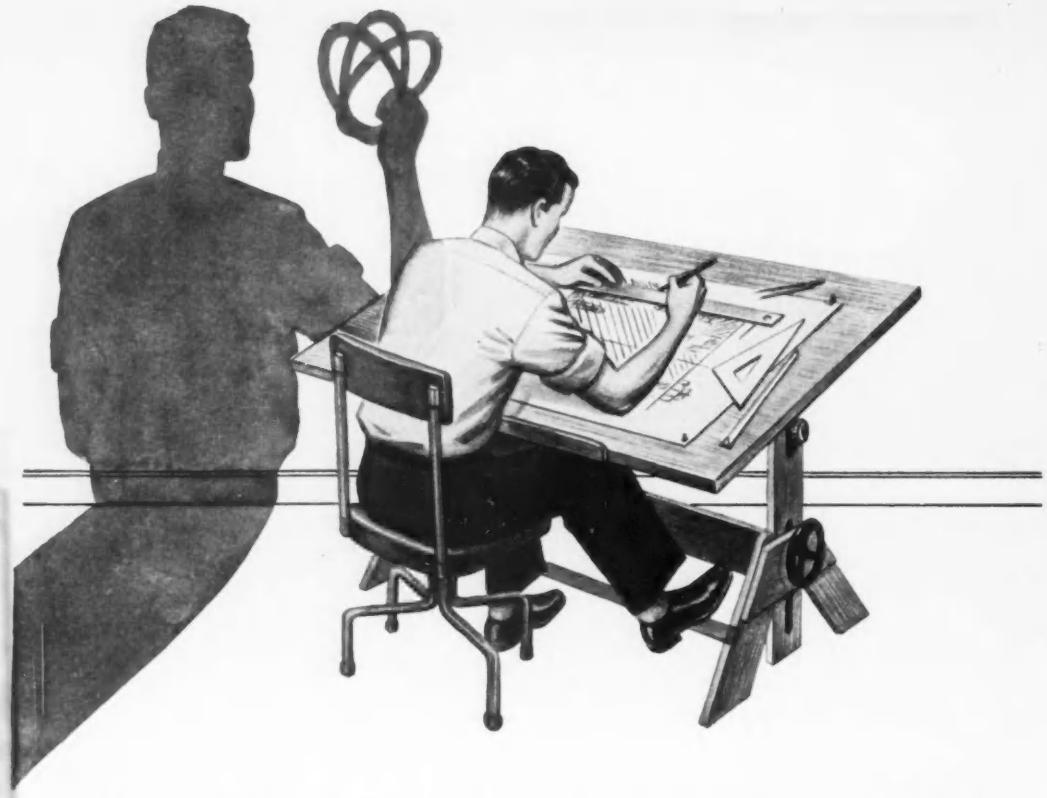

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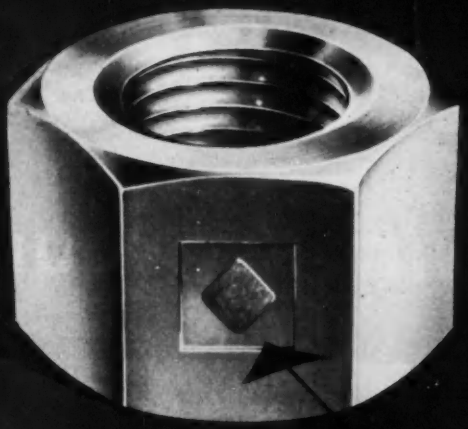

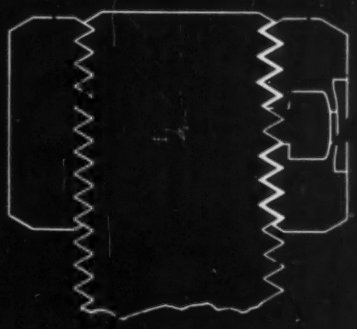

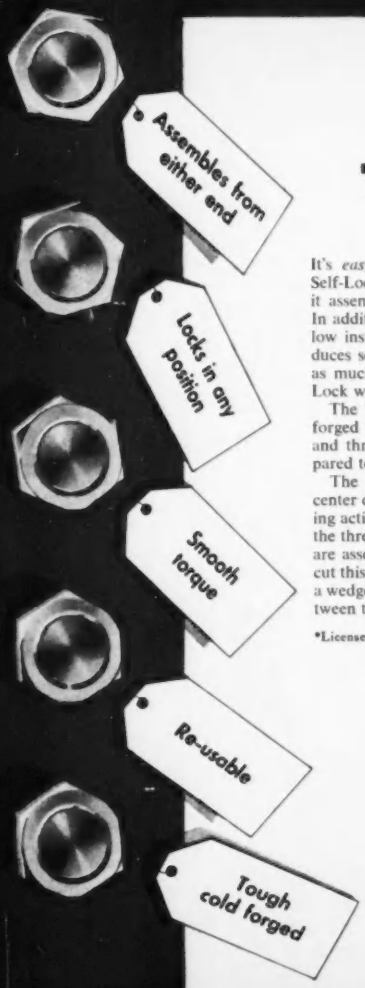

Easy Does It With

Townsend Nylok Locknuts

It's *easy* to install the new Townsend Nylok Self-Locking Nut* as it has no top or bottom—it assembles readily even in blind applications. In addition, you get positive locking action with low installation torque. This saves time and reduces scrap losses due to seizing and galling by as much as 80% over other types of locknuts. Lock washers and jam nuts are eliminated.

The Townsend Nylok Type "E" Nut is cold forged to provide added strength in the body and threads and to save critical material compared to nuts machined from bar stock.

The small nylon plug insert located in the center of one of the hex faces provides the locking action. This plug extends beyond the crest of the threads in the nut and when the nut and bolt are assembled the bolt compresses but does not cut this nylon plug. The nylon plug then reacts as a wedge creating strong metal to metal action between the male and female threads.

*Licensed under The Nylok Corporation patents.

Nylok nuts lock in any position. Seating is unnecessary. Due to nylon's ability to retain its original shape, these nuts can be used again and again. This feature makes it especially desirable in setting adjustment screws. Nylok nuts have high tensile strength, excellent heat resistance and are unaffected by most chemicals.

The Townsend Nylok Locknut is available in American Standard Light (E-6) and Light-Thick (E-7) series—in sizes ¼" through ⅜". It is a suitable companion to Townsend's Tufflok Nut which is a one-piece cold forged nut, with a hexagonal fibre washer as the locking medium. Both locknuts have been highly successful in offsetting vibration and shock. They have back of them Townsend's 135 years of experience in wire drawing and cold heading.

For information on how to save time, eliminate waste and produce better equipment with Townsend Locknuts, write for our locknut bulletin.

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Short cuts worth following in your

In drafting **Costly retracing is eliminated in producing drawings which include standard components.** The functioning of many IBM machines can be changed by adjusting the wiring on the plug-board panels. And in order to give customers a record of the wiring combinations they will use—without retracing the standard panel detail time after time—IBM follows this short cut:

It makes photographic intermediates of its plug-board panel drawings by reproducing them on Kodagraph Autopositive Paper. Then, to these sharp, clean, translucent prints, the draftsmen simply add the various wiring arrangements . . . and "masters" are available—ready to produce the required number of direct-process prints.

How IBM produces Autopositives

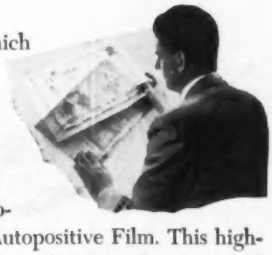
It's an easy, economical operation—revolutionary when compared to other methods of producing photographic intermediate prints.

First of all, Kodagraph Autopositive Paper produces positive photographic intermediates directly—without a negative step. Furthermore, it can be *handled* in ordinary room light . . . *exposed* in a direct-process (or blueprint) machine at uniform, practical speeds . . . *processed* in standard photographic solutions. And the result—a sparkling intermediate with dense black photographic lines on a white, durable, translucent paper base.

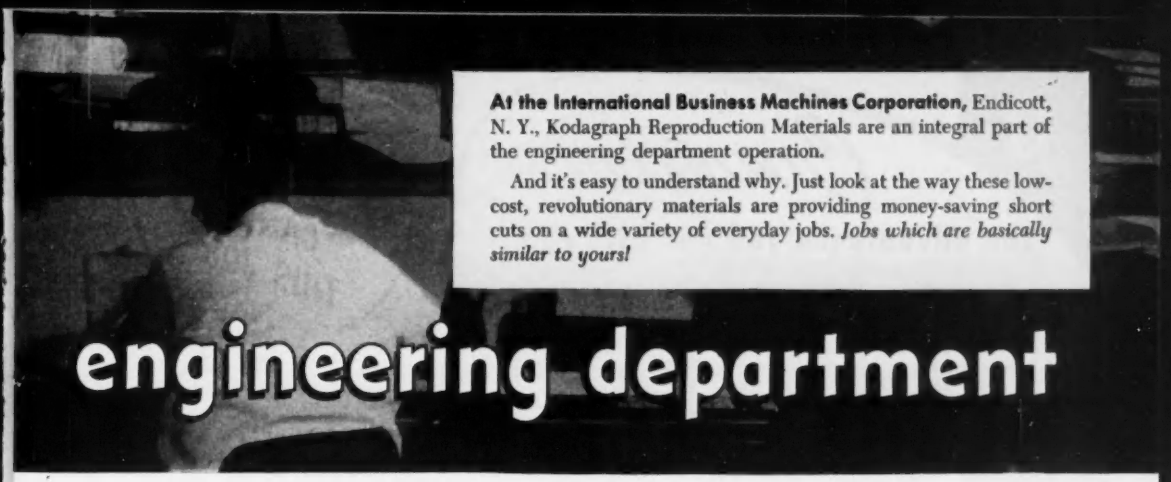
In copying blueprints

How to get extra copies of blueprints and direct-process prints *quickly and economically* . . . is no problem for IBM. These prints are used to exchange design information between the plants in Endicott and Poughkeepsie, N. Y. Whenever extra copies are needed for the shop, the necessary print-making intermediates are made directly—in both plants—simply by reproducing the blueprints on Kodagraph Autopositive Paper.

In reclaiming old drawings



Some IBM drawings which show the effects of long service—which are discolored, weak in detail, and slow-printing—are reproduced on Kodagraph Autopositive Film. This high-contrast, direct-printing photographic material (which is handled like Autopositive Paper) cleans up backgrounds . . . intensifies line detail—produces intermediates which have dense black photographic



At the International Business Machines Corporation, Endicott, N. Y., Kodagraph Reproduction Materials are an integral part of the engineering department operation.

And it's easy to understand why. Just look at the way these low-cost, revolutionary materials are providing money-saving short cuts on a wide variety of everyday jobs. *Jobs which are basically similar to yours!*

engineering department

images on Kodak's famous safety film base. Intermediates which deliver sharper, cleaner prints *at top machine speeds.*

In preparing instruction manuals

Kodagraph Autopositive Film is used for another job—to reproduce printed handbook material . . . including halftone illustrations, line sketches, diagrams and text. And in doing so, it holds the faintest line . . . keeps close lines from filling in. As a result the direct-process prints which IBM makes from Autopositive Film intermediates are sharp and clear in every detail . . . easy for customer-trainees to follow.

In duplicating engineering department reports

As many as 25 copies are needed of the monthly engineering department reports, which are prepared on IBM tabulating machines. The quickest, easiest way of getting them, IBM finds, is to make intermediates on Kodagraph Contact or Autopositive Paper, and from them run the required number of direct-process prints.

When the reports are on big sheets, a reduced-scale negative is made. This is then exposed on Kodagraph Contact Paper . . . and a positive intermediate is made *directly.*

When no reduction in size is necessary, a Kodagraph Autopositive intermediate is produced.

Kodagraph Autopositive Materials

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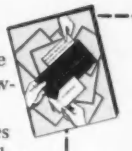

Write today for a free copy of "Modern Drawing and Document Reproduction." It gives complete details on the revolutionary line of Kodagraph Reproduction Materials, which you, or your local blueprinter, can process *conveniently, economically.*

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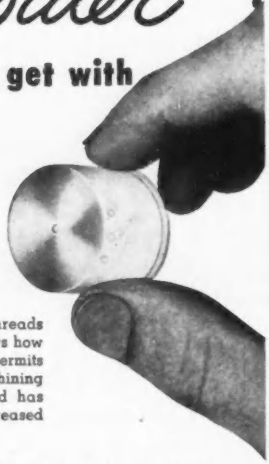


This coil form with 128 threads per inch on the O.D. shows how nylon's machinability permits close tolerance work. Machining coil forms from nylon rod has resulted in greatly increased strength of threads.

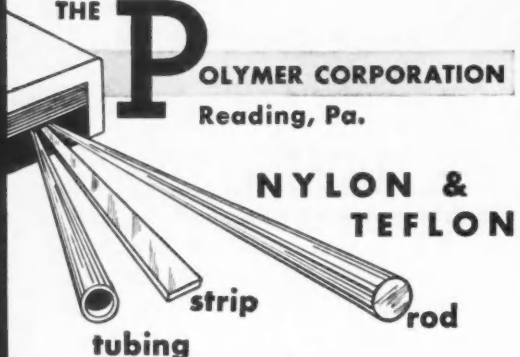
Because of the STRENGTH of nylon rod, bearing retainers and screws are being machined from it. WEAR RESISTANCE is important for parts like gears; and where lubrication is difficult, nylon gears are outlasting metal gears by as much as 2 to 1. The SELF-LUBRICATING properties of parts machined from nylon rod contribute to long and QUIET OPERATION of gears, bearings, thrust washers, etc. The production advantages of nylon rod are tremendous—

Rush Production—No waiting for costly molds when you machine parts from nylon rod.

Design Flexibility—You can change a part's design by merely changing the machining set-up.

Close Tolerances—Particularly in heavy cross-sections, machining gives closer tolerances than are possible by molding nylon.

New Folder Contains Complete Information on sizes, nylon formulations and colors available, etc. Write for your copy.



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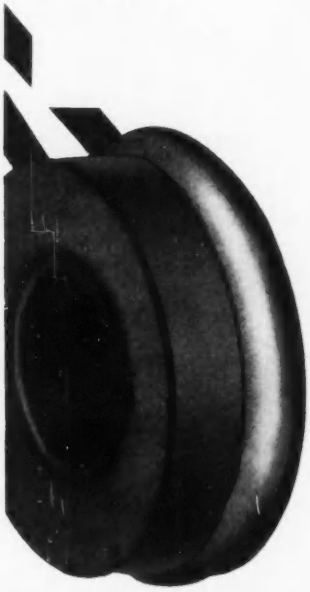
This Bobbin Type Coil is supplied to clock makers: Some use 37#, others may specify 38# or 40# wire; Deep wax or lacquer impregnation; enamel, formex, or nylon wire insulation. At Coto, it is *usual* to work to close tolerances.



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Cherry Blind Rivets save time...speed production on Douglas Skyraider

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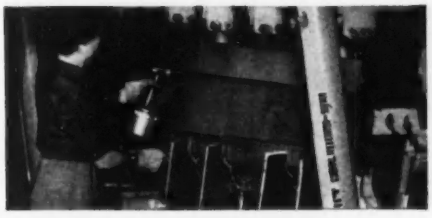
Flying from carriers like the Valley Forge and Philippine Seas, these planes have demonstrated the effectiveness of this versatile Douglas design. To date, multiple variations of the airplanes have been manufactured, and in each design, Cherry Blind Rivets are specified in the fabrication of elevators, dive brake assemblies and other important parts.



Douglas, like many other top-flight companies, uses Cherry Rivets to help make their hard jobs easy. In the production scene at left, notice how Cherry Rivets are used to close off the inner skin of the dive brake assembly.

Cherry Rivets are installed by one man from one side of the work. They eliminate the two-man crew used to buck solid rivets. It's a pulling action that does the work—no exploding, no twisting, no hammering.

Ideal for box sections, tubes, ducts and other "hard-to-get-at" spots, Cherry Rivets speed assembly—save man hours—cut unit costs. If you're not familiar with the time-saving potentials of Cherry Rivets, take a moment now to write for full information.

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a Variety of Enclosures

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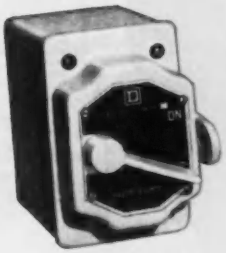
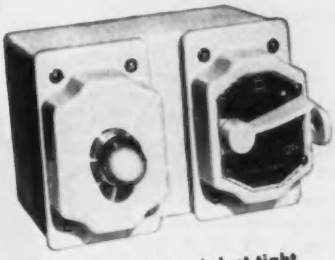
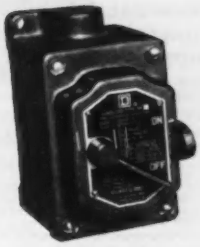


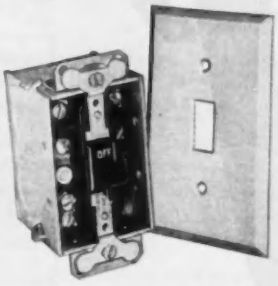
Water-tight and **dust-tight** enclosure



Water-tight and **dust-tight** with pilot light



Explosion-resisting enclosure. For hazardous locations—Class I Group D and Class II Groups E, F and G.



Flush mounting. Basic starter mechanism can be used with standard switch box and flush plate—or with flush plate only for machine tool cavity mounting.

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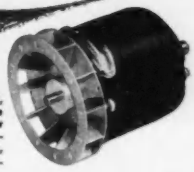

Compactly designed, capacitator-type induction motor for wire recorders, electronic tube cooling, and similar services.

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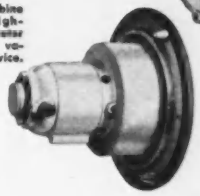
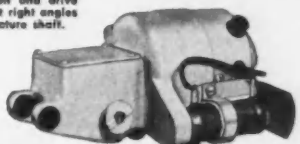


Heavy-duty turbine driven by a high-speed universal motor for commercial vacuum cleaner service.

Planetary inbuilt speed reducer permits a straight-line drive, symmetrical construction; insures good performance.



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The long life and dependable day-in and day-out service for which Lamb Electric Motors are known, results largely from the fact that they are designed to provide the exact electrical and mechanical requirements for each product they drive.

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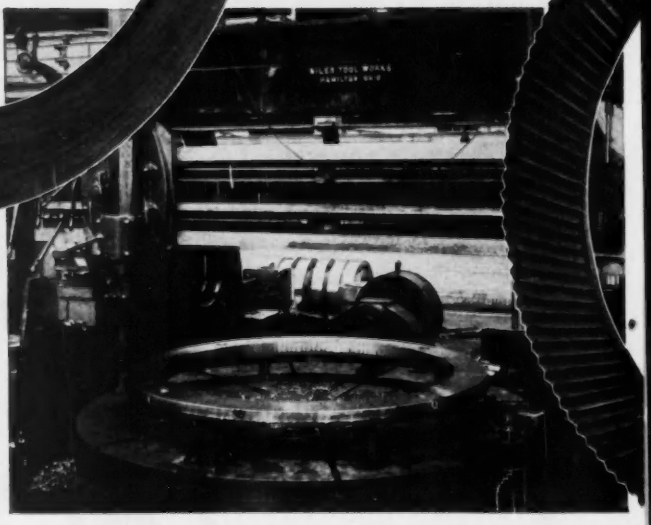
Standard Weldless Ring Blank, rolled to close tolerances for conversion to a table rack spiral bevel ring gear for a boring mill.



Finish-machining the ring gear on a Niles vertical boring mill. Teeth have already been cut.

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The finished ring gear. Uniform metal structure assures high precision in gear tooth form and dimension.

The job of the table-rack spiral bevel ring gear on a modern boring mill is rough, rugged and responsible—and the only way to get the essential physical properties *in the gear* is to have them *in the blank*. Strength—to take the stress and strain of high-speed production with deep-cutting carbide tools. Uniform structure—to permit the precision machining that is the basis of precision operation. Accuracy in dimension—to save machining time and waste.

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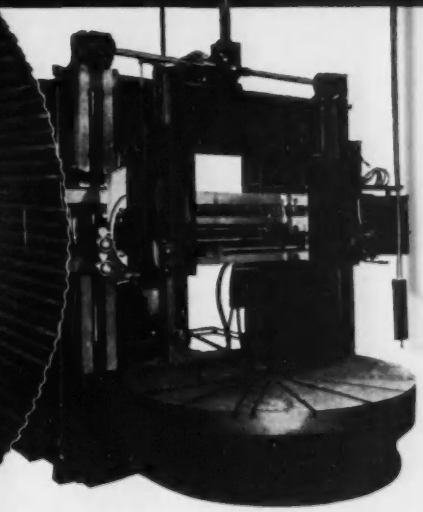

Niles 10-foot hydraulic feed vertical boring mill; table is driven by the gear shown. This is a high-production machine, for use with carbide tools—which calls for high strength in the drive gear.

-LIMA-HAMILTON

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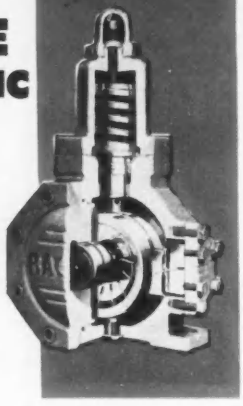
Simplify your Circuit



Less valves and controls in a circuit provide easier installation and lower initial costs.

RACINE "Variable Volume" Pumps eliminate relief valves and extra piping. They reduce horsepower requirements and avoid excessive heat losses. Over-all cost of motor and reservoir is usually reduced. Efficiency is high because RACINE Pumps "put all of the oil to work."

A wide range of governor controls provide pumping action at the proper pressure and volume to handle any given job most effectively. These interchangeable governors are an exclusive RACINE feature.

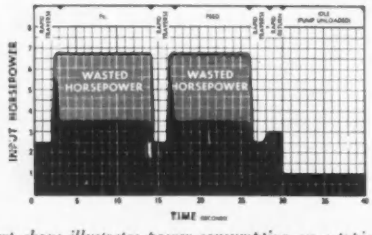


Chart above illustrates power consumption on a typical machine tool. Black area is power used with a No. 2 RACINE "Variable Volume" pump controlled by a pressure compensated feed value. Area in color is power wasted by a constant volume pump, bypassing most of its volume through a relief valve during the feeding cycle.

OTHER RACINE HYDRAULIC PRODUCTS

Four-Way Valves

Pressure Boosters

Pump & Reservoir Units

Write for new 3-color Catalog P-10-D covering RACINE's complete line of "Variable Volume" Pumps, Valves and Pressure Boosters.

RACINE TOOL AND MACHINE CO.

1772 State Street, RACINE, WISCONSIN, U. S. A.

IMPORTANT DATA ON

UNIVERSAL *Flexible* METAL HOSE

for conveyance of gases, liquids, semi-solids, dust, etc.—for moisture-proof armored conduit and control casings—and many other applications.

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UNIVERSAL METAL HOSE CO.

2145 South Kedzie Avenue Chicago 23, Illinois

One PALNUT SELF-LOCKING NUT replaces Two or Three parts
For quick, secure fastening at low cost!
PALNUT SELF-LOCKING
TRADE MARK
NUTS and FASTENERS
THE PALNUT COMPANY 10 Cordier St., Irvington 11, N. J.

Fine machines begin with FINE BEARINGS

Despite the emergency you are probably doing some long-range planning . . . exploring the possibilities of the day when all-out production of civilian goods will again demand emphasis on advanced design.

In exploring the possibilities of your products' future, it will pay you to remember this basic truth: Fine machines begin with fine bearings . . . and "fine bearings" is simply another way of saying Ahlberg Bearings.

For more than four decades design engineers have found that Ahlberg Bearings offer outstanding opportunities for improving design, increasing stamina, reducing maintenance and cutting cost.

Of course, right now, early delivery promises on non-military requirements are next to impossible, but there's never a shortage of sound engineering service at Ahlberg. Please feel free to ask for it at any time. Ahlberg Bearing Company, 3025 W. 47th St., Chicago 32, Illinois.

AHLBERG

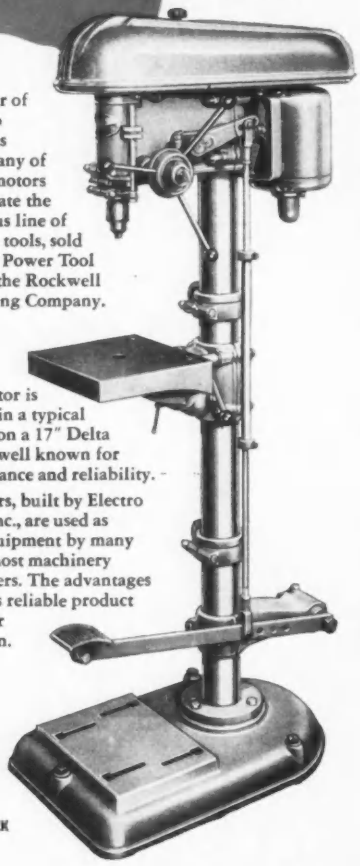
BALL BEARINGS

ENGINEERED AND BUILT FOR THE WORLD'S FINEST EQUIPMENT

AUTOMOTIVE . . . INDUSTRIAL . . . AIRCRAFT . . . MARINE . . . ARMAMENT

Delta® Tools
get Dependable Power

FROM DOERR* MOTORS



For a number of years Electro Machines has furnished many of the electric motors used to operate the world famous line of Delta power tools, sold by the Delta Power Tool Division of the Rockwell Manufacturing Company.

A Doerr motor is shown here in a typical application on a 17" Delta Drill Press, well known for top performance and reliability.

Doerr Motors, built by Electro Machines, Inc., are used as standard equipment by many of the foremost machinery manufacturers. The advantages of using this reliable product deserve your investigation.

*TRADE MARK

If you have a particular motor problem please let us hear from you.

NORTH THIRD STREET
CEDARBURG, WISCONSIN

FROM 1/20 to 2 H.P.

DOERR MOTORS

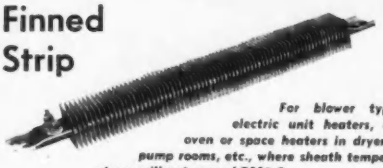
Standard or Designed to Your Specifications

ELECTRO MACHINES, INC

VULCAN

ELECTRIC HEATING UNITS

Finned Strip



For blower type electric unit heaters, as oven or space heaters in dryers, pump rooms, etc., where sheath temperatures will not exceed 750° F.

CONSTRUCTION

Sheath of one piece rectangular tubing. All fins are in close contact with the surface of the heating element, thus assuring efficient heat transfer.

Sheaths are rust-resistant steel. Terminal screws are stainless steel.

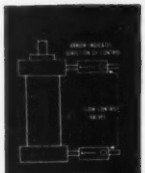
Heater coil nickel chromium wire, insulated from inner sheath wall with a refractory.

15 stock lengths, from 500 watts, 10½" overall to 3250 watts, 41½" overall, for both 115 and 230 volts.

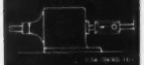
VULCAN ELECTRIC CO.
DANVERS 18, MASS.
the makers of Vulcan Electric Soldering Tools, Solder Pots, Glue Pots and Branding Irons

FLOW CONTROL VALVE

for Cylinder Speed Adjustments OVER A WIDE RANGE IN AIR OR HYDRAULIC USE



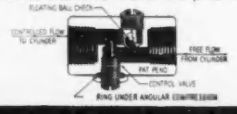
INLET SPEED CONTROL
For Double Acting Cylinders



SPEED CONTROL for Single Acting Air or Hydraulic Cylinder

The Pneu-Trol Flow Control Valve combines an efficient Stainless Steel FLOATING BALL CHECK which opens and closes at the slightest change in flow direction, with a Vernier Type VARIABLE NEEDLE ORIFICE adjustment in a compact control which has widened air and hydraulic cylinder application by providing precise control of cylinder action. Modifications of the Pneu-Trol Valve are available as Plain Check, check with Fixed Orifice (orifice drilled by customer in the Standard Check Valve), Needle Valve and Velocity Limiting Check, as illustrated at left. All Pneu-Trol Valves are made from bar stock in brass (up to 1000 psi) or steel (5000 psi) or other body metals to your specifications. All internal parts are Stainless. All valves available in 5 sizes—⅛", ¼", ⅜", ½", and ¾".

Attractive prices — immediate delivery. Write for illustrated circular and price list.



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Pneu-Trol Devices, Inc.
1428 N. Keating Ave., Chicago, Ill.

Is this the **INFORMATION** *you are looking for?*

SHEET SIZES

Gauge	#36B&S (.0050) and heavier
Width	1/8" to and inc. 14"
Lengths	Commercial
Circles	2" to 14" in dia.
Coils or Rolls	Gauges .090 and thinner

SEYMOUR No. 950
Grade A Phosphor Bronze

95% Copper • 5% Tin

Outstanding characteristics of Seymour Phosphor Bronzes are their great toughness, ability to retain resiliency under countless flexures, resistance to wear, good electrical and thermal conductivity, good bearing qualities, high resistance to corrosion. Write for your copy of SEYMOUR PHOSPHOR BRONZE containing important data on sheet, wire and rod.

SPECIFICATIONS

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Federal	QQ-B-746
A.S.T.M.	B-103-42T
A.M.S.	4510
S.A.E.	77

USES

- Springs
- Diaphragms
- Fuse Clips
- Lock Washers
- Perforated Sheets
- Thermostatic Controls
- Microphone Assemblies
- Electrical Devices

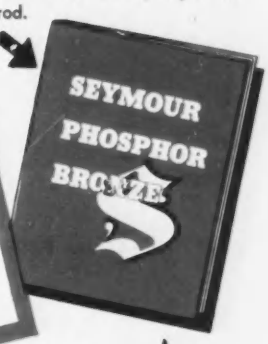
TEMPERS

	B. & S. Numbers Hard	Tensile Strength Lbs. Per Sq. In. Min.	Max.
Soft	0	40,000	55,000
Half Hard	2	55,000	70,000
Hard	4	72,000	87,000
Extra Hard	6	84,000	98,000
Spring	8	91,000	105,000
Extra Spring	10	96,000	109,000

Based on Tests of Sheet .040 Thick

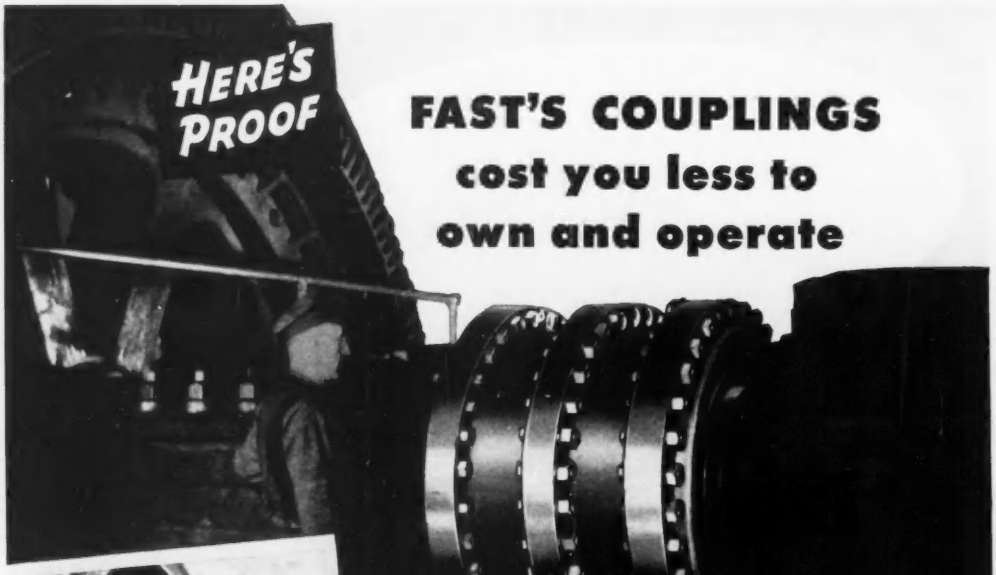
PROPERTIES

	Spring Temper	Soft
Elongation % in 2"	1.5	50
Rockwell B 1/16" Ball 100 KG Load	95	30
Density—lbs. per cu. in.	.322	
Elec. Cond % I.A.C.S. at 20°C.	16.5	
Thermal Cond. BTU	47	
Polishing	Excellent	



THE SEYMOUR MANUFACTURING COMPANY, SEYMOUR, CONN.

SEYMOUR



FAST'S COUPLINGS cost you less to own and operate

ON BILLET MILL SINCE 1923

ON GAS BLOWER SINCE 1920

ON AMMONIA COMPRESSORS SINCE 1922

Fast's Couplings cost you less per year because they normally outlast the equipment they connect. That means their reasonable cost can be spread out over 20 years or more . . . assuring low-cost service without excessive maintenance costs!

Fast's basic design is *foolproof!* Instead of a perishable oil seal, Fast's are the only couplings to use a *permanent* metal-to-metal closure. Oil is always maintained at a safe level . . . whether the coupling is running or standing still . . . and dirt cannot get in. Fast's Couplings are compact, yet large enough to stand up under punishing service for 20 years or more!

When you specify Fast's Couplings, you get Koppers' valuable engineering service. In many cases where a special coupling appears necessary, Koppers engineers can modify a standard Fast's and save you money! Get the facts on Fast's Couplings. Mail the coupon for your copy of Fast's *free* Catalog today!

Mail Coupon for FREE Catalog

KOPPERS CO., INC., Fast's Coupling Dept.,
237 Scott Street, Baltimore 3, Md.

Gentlemen: Send me Fast's Catalog which gives detailed descriptions, engineering drawings, capacity tables and photographs.

Name .....

Company .....

Address .....

City ..... Zone ..... State .....

KOPPERS

FAST'S
THE ORIGINAL
GEAR-TYPE
Couplings

INDUSTRY'S STANDARD FOR 31 YEARS

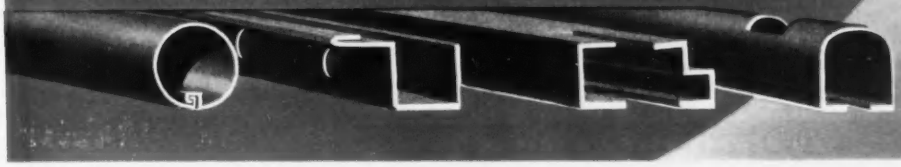
roll formed shapes . . .

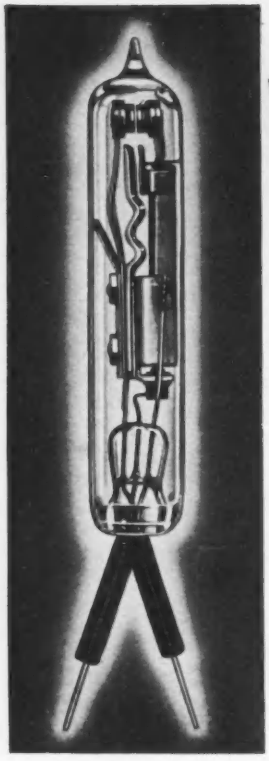
● We take the difficult production jobs off your shoulders. Roll forming equipment speedily turns out intricate sections . . . sized, notched and punched to your specifications. Shapes are rolled with dies that are precision-made in our own plant. Write for descriptive brochure.

ROLL FORMED PRODUCTS *Company*

MAIN OFFICES AND PLANT

3760 OAKWOOD AVE. • YOUNGSTOWN, OHIO





Brains in **GLASS...** to last a lifetime

EDISON

THERMOSTATS operate quietly for years, free from outside contamination

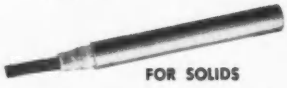
Sturdy glass is the perfect enclosure to protect the fine mechanism of these EDISON Thermostats. Sealed-in-glass means freedom from powdered particles, corrosive gases, calibration drift and contact arcing. And, since the entire unit is isolated in an inert gas, time (measured in years) has no apparent effect, whether the contacts operate every few seconds or remain dormant—as in fire alarm devices.

FOR AIR

EDISON THERMOSTATS are available in several standard mountings. Send for free Bulletin No. P-3009.

SPECIFICATIONS:

Vibration	.031" amplitude at 60 cps.
Impact	50 g.
Contact load	8 amperes max. to 250 V. ac/dc
Temperature	320° C max.



FOR SOLIDS

FOR LIQUIDS

Thomas A Edison
INCORPORATED

Instrument Division
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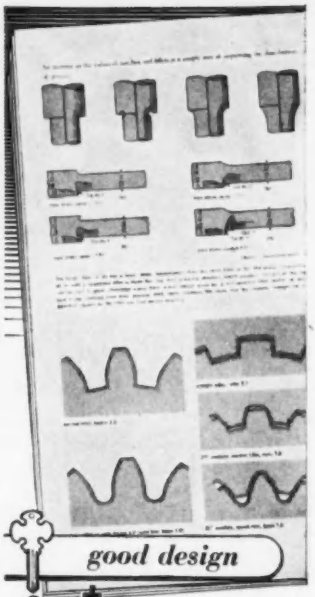
Sealed Time Delay Relays • Sensitive Relays • Electronic Temperature Controls • Critical Temperature Monitors • Electrical Resistance Bulbs.

YOU CAN ALWAYS RELY ON EDISON



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If you are a design engineer seeking success with steel components, you will find help towards your goal on every page of this 72 page booklet. Write now for "3 Keys to Satisfaction"—it is valuable and it is free.

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MOLY

Stop High-Pressure Leaks and Blow-offs

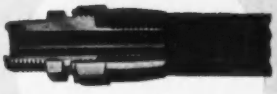
—with ANCHOR Ductile Sleeve Hose Couplings

Factory application of Anchor's exclusive Ductile Sleeve Coupling is your best insurance against leaks or blow-offs. Our superior grip gives you a plus margin of safety and a minimum time loss due to lay-up of equipment.

Here's how it works (referring to the illustration): Cover stock (G) is removed from the hose by grinding and buffing. Ductile Sleeve (C) is slipped on the end of the hose over the bare wire. Coupling body (A) with steel insert (B) attached is placed in position on the hose. The coupling is then swaged radially on the hose, imbedding the ductile sleeve into the internal grooves of the coupling shell (E) and into the mesh of the wire braid reinforcement (F). This is the exclusive Anchor patented grip.

Some of the applications of Anchor high-pressure flexible oil lines include high-pressure riveting, road machinery, snow plows, coal mining machinery, material handling machinery, machine tool applications, agriculture, railroads, oil field machinery, liquefied petroleum gas, lubrication and various other installations.

Clamp-type Couplings



2-Piece Re-usable Couplings

NPTF Straight Adapter Unions

45°-90° Adapter Unions

Other styles of related fittings available for piping installations

ANCHOR COUPLING CO. INC.

Factory Libertyville, Illinois • Branch Detroit, Michigan

Send for complete information on Anchor assembled hose units.

Clip coupon to company letter head —and mail TODAY!

ANCHOR COUPLING CO. INC. Dept. PE41
Libertyville, Illinois

I want engineered-information on cost-cutting Anchor Ductile Sleeve Hose Couplings. Please send me Bulletin No. 48.

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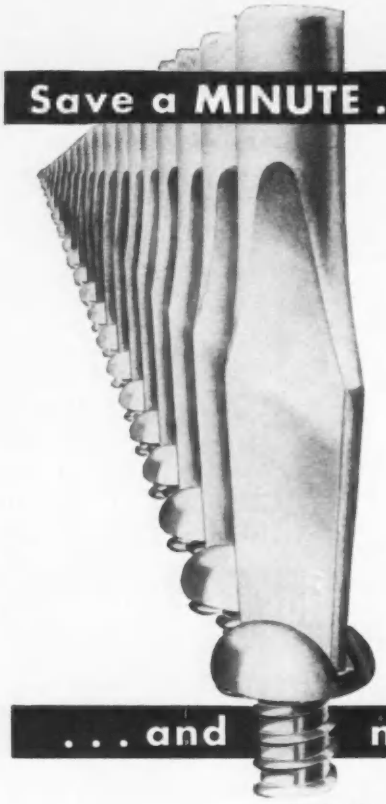
9-5



Save a MINUTE . . .

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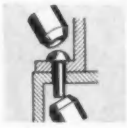
BOLTS, NUTS AND LOCK WASHERS

here...

MACHINE SCREW IN TAPPED HOLE

here...



RIVETING IN HARD-TO-REACH PLACES

here

MACHINE SCREW IN THREADED INSERT

. . . and multiply it by MILLIONS!

A simple idea — Self-tapping Screws — originated 35 years ago by Parker-Kalon — becomes more important to industry every day.

The idea is simple—hardened screws that will drive into metal or plastics just as wood screws drive into wood—to save the time and equipment required for tapping, riveting, and nut-running.

But its accomplishment is far from simple. The foundation of P-K leadership was its success in mastering the difficult problem of mass-producing screws possessing the proper balance of hardness and toughness. It is the reason the names Parker-Kalon and Self-tapping Screws are synonymous today.

IF IT'S P-K IT'S O.K.

Your savings with P-K Screws—at each fastening point—are measured in minutes or less. But these minutes—multiplied by millions of fastenings—mount rapidly. They *total* a big saving—a saving you can't afford to overlook with production demands soaring, production costs at an all-time high, and with a squeeze on profits.

Why not let a P-K Assembly Engineer help you to plan your DO, or other assemblies, in order to take full advantage of the *economical* Self-tapping method? Parker-Kalon Corporation, 200 Varick Street, New York 14, New York. Sold through Accredited Distributors.

The Original

PARKER-KALON® SELF-TAPPING SCREWS

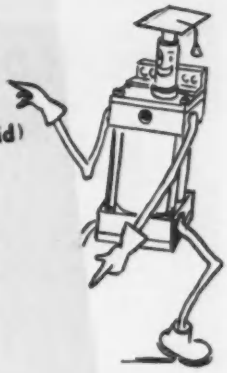
A TYPE AND SIZE FOR EVERY METAL AND PLASTIC ASSEMBLY

BOOST
80 PSI AIR

(Input Range: 40 to 3000/psi Air or Fluid)

TO . . .
2000 PSI HYDRAULIC PRESSURE

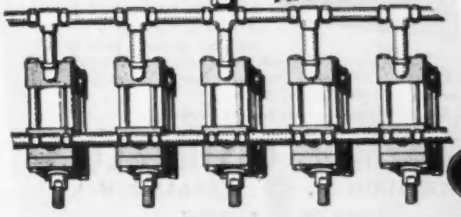
(Output Range: 200 to 10,000 psi Fluid)



Especially Recommended for . . .

- WELDING
- PUNCHING
- SHEARING
- CLAMPING
- RIVETING
- CRIMPING
- PRESSING

and SIMILAR APPLICATIONS



with Miller

Fluid Pressure BOOSTERS

From ordinary plant air line pressure, Miller Boosters produce hydraulic pressures (from 200 to 10,000 psi) for driving one or more hydraulic work cylinders simultaneously at from 30 to 450 strokes per minute. Ordinarily, the booster operates one stroke for each stroke of the operated work cylinders.

Used in place of conventional type hydraulic pumps, Miller Boosters save space and weight, permit convenient portability and are easier and less costly to install, operate, and maintain. Also, they hold pressure *indefinitely —without the motion and heat generation of ordinary pump circuits.*

Used in place of air cylinders, the booster driven hydraulic work cylinder, which can do the work of an air cylinder ten times as large and heavy, saves space and weight at point of application of cylinder thrust—since the booster itself can be mounted separately—away from the hydraulic work cylinder—and either on or off the equipment or machine.

In many installations, the popular Miller Dual Pressure "Air Miser" Booster *saves up to 95% of the air* normally consumed by direct-driven air cylinders.

A wide selection of sizes, pressure ratios and mounting styles are available for the first time at low cost on a normal delivery schedule because Miller Boosters are built up from stock Miller standard cylinder parts to eliminate costly designs, patterns and castings.

Full Details In Miller Bulletin B-200 Sent FREE On Request

OTHER MILLER PRODUCTS INCLUDE: AIR CYLINDERS, 1½" to 20" BORES, 200 PSI OPERATION; LOW PRESSURE HYDRAULIC CYLINDERS, 1½" TO 6" BORES FOR 500 PSI OPERATION, 8" TO 14" BORES FOR 250 PSI; HIGH PRESSURE HYDRAULIC CYLINDERS, 1½" TO 12" BORES, 2000-3000 PSI OPERATION. ALL MOUNTING STYLES AVAILABLE.

Miller

MILLER MOTOR COMPANY

2002-04 N. HAWTHORNE, MELROSE PARK, ILL.

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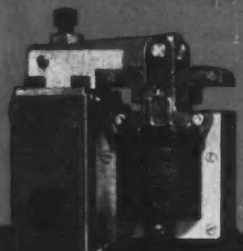
Sales and Service from coast to coast

SOLENOID VALVES

have working pressures range as high as 3000 psi. They were specifically designed for remote push button control of hydraulic systems, as well as for the handling of any non-corrosive fluids. The poppet construction eliminates leakage. The impregnated coils are oil and moisture resistant. The unit can be mounted in any position.



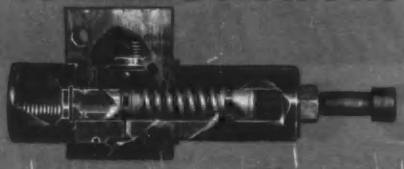
PRODUCTS OF

Waterman

ENGINEERING COMPANY

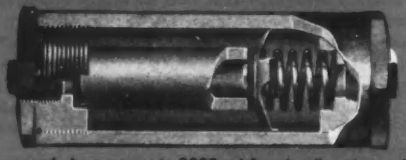
725 CUSTER AVENUE
EVANSTON, ILLINOIS

ADJUSTABLE FLOW REGULATORS



for cylinder speed control over a 50% range are built for pressures to 3000 psi. Model 320 shown meets requirements for cylinder speed adjustment yet maintains constant speed regardless of work or pressure fluctuations. There are types for Machine Tools—Earth Moving, Material Handling and Farm Equipment—Packaging Machinery—Steel and Paper Mills—Refineries—Oil Fields and Printing Presses.

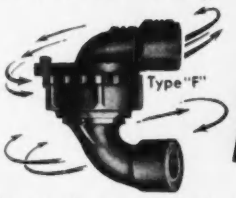
MICRONIC LINE FILTERS



are made in pressures to 3000 psi for air, oil, water and other fluids. They are compact permitting more simplified design, have built-in durability, and are easy to clean. The Micronic element filters to 40 Microns providing full protection for pumps, valves and cylinders. The elements which are low in cost are easily replaced. They make possible maximum flow with a minimum pressure drop.

WRITE FOR OUR ENGINEERING COOPERATION AND FURTHER DETAILS

. . . with 360° swing



FLEXO "The Joint That Travels In The Best Circles"

through moving pipe lines

• WHEN YOUR PROBLEM is conveying STEAM, AIR, WATER, OIL, etc. under high or low pressures through moving pipe lines or to equipment in motion, it pays to use *safe, dependable* Flexo Joints. Designed for 360° swivel movement, they combine the flexibility of hose and the strength of pipe . . . assure *full, free* flow at all times.

FEWER PARTS . . . LESS MAINTENANCE

Precision-made Flexo Joints contain just four simple parts *completely* enclosed from grit and dirt — no springs . . . no small or complicated parts . . . no ground surfaces to wear.

IMMEDIATE SHIPMENT . . . ALL STYLES, SIZES

Made in four styles for standard pipe sizes from ¼" to 3".

No need to worry about carrying stock. Flexo Joints are sent *where* they're needed *when* they're needed.

WRITE FOR COMPLETE LITERATURE

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NEW BOOKLET!

PRECISION "INVESTMENT CASTING" . . . its uses and applications

For design engineers and production executives

Here is a 12 page definitive treatment in words and pictures of the precision INVESTMENT CASTING process.

For close tolerance parts in difficult-to-machine metals, and with intricate contours . . . INVESTMENT CASTING is the fastest . . . the least expensive . . . one of the most accurate methods of production.

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PRECISION CASTINGS

Quality control...

another feature of Accurate service

A portion of the elaborate quality control equipment in use at Accurate.

. . . and it lowers

the overall cost of your springs

THE uniformly high quality of Accurate springs . . . their rigid adherence to the customers specifications . . . are the natural result of the combination of skilled springmakers and the most modern springmaking machines *plus* painstaking quality control procedures. Quality control is just one of the features of Accurate service. Certainly, we could "get by" without it like so many other spring manufacturers do. But we have found it pays off handsomely for our customers *and* ourselves. The customer gets uniformly good springs with savings in time and money because there are fewer rejects and assembly runs more smoothly. We come out ahead because our customers are pleased and we're not subjected to a flood of substandard "returns." In the overall, it means lower costs for everyone.

The best way to find out what we mean is to give us a trial. For a quotation just send a drawing and specifications or, if you prefer, Accurate engineers will be pleased to give their assistance in developing new or improved design. ACCURATE SPRING MFG. CO., 3815 W. Lake St., Chicago 24, Illinois.

Write for your copy of the new revised Accurate Handbook of Technical Data on Springs. This booklet has been out of print for some time and if you have previously requested a copy and have not received it, we would appreciate your asking again.

Be sure the springs you buy are Accurate

Accurate Springs

Springs
Wire Forms
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MUELLER BRASS CO.

600 series a better bearing bronze containing no hard-to-get tin

If you use gears, connecting rods or other parts of bearing metal in your products, it will pay you to investigate Mueller Brass Co. "600" series, a forgeable bronze that *contains no critical tin*. This bearing metal outperforms phosphor bronze and other bearing metals and will save you money in your applications. "600" series bearing metal can be forged into relatively complicated shapes and produces a forging of close-grained homogeneous structure impossible to get in a casting. The forged shape is closer to finished size than a casting and requires less machining. "600" series alloys have a low coefficient of friction, a tensile strength 2½ times greater than cast phosphor bronzes and a high resistance to corrosion. "600" has a 25 year record of outstanding performance on some of the toughest bearing applications. There is a "600" series alloy with the properties to fit your bearing metal needs . . . write today for further facts.

Four typical parts forged from Mueller Brass Co. "600" series Bearing Bronze.

MUELLER BRASS CO.

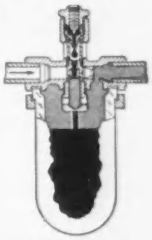
PORT HURON 16, MICHIGAN 84

NEW Norgren MICRO-FOG Lubricator

REVOLUTIONARY PROGRESS IN AIR LINE LUBRICATION

This new Micro-Fog Lubricator by "The Pioneer in Oil Fog Lubrication" breaks each drop of oil down into extremely fine uniform size particles (dia. 2 microns —.00007874"—or less) that REMAIN IN SUSPENSION for an indefinite period of time.

- **Micro-Fog** travels far greater distances. Location of lubricator in relation to units served is no longer a critical factor.
- **Micro-Fog** can be uniformly distributed to several outlets—serving multiple units operating simultaneously.
- **Possibility** of flooding lines or equipment is reduced to the very minimum.
- **Air flow requirement** is greatly reduced. Constant, uniform delivery of oil fog is precision-controlled—down to as little as one drop in 20 minutes delivered into the air stream, if required.[1]
- **Accomplishes** more thorough lubrication. Completely automatic. Fully-visible oil feed and supply.
- **Product of years** of research and development, plus over 20 years know-how in air line lubrication. Fully field-tested and approved in many industries.



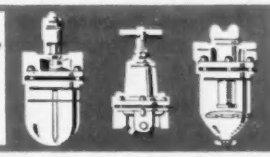
How the Norgren Micro-Fog is created: Air entering lubricator picks up drops of oil fed into air stream, creating an oil fog in the bowl. Heavier particles of the oil fog are returned to the oil supply. Only the finest particles of .00007874" in diameter or less, representing only 5% of oil flow seen through sight glass, is carried into the air line.

25th Year of Progress

Ideal for high speed grinding spindles...small air tools...gear boxes...multiple taps & drills...air sanders...many other exacting applications.

Write for BULLETIN 425—C. A. Norgren Co., 228 Santa Fe Drive, Denver 9, Colorado

Norgren

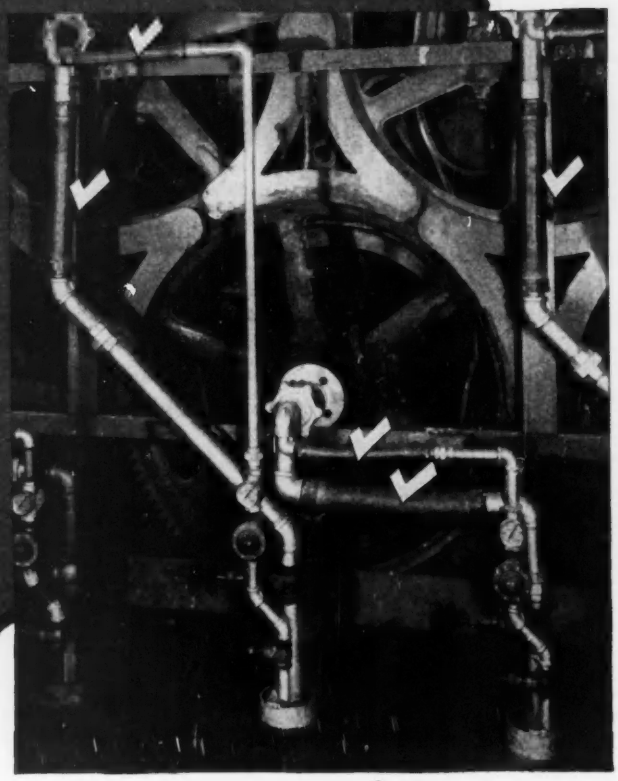


Lubricators, Regulators, Filters, Relief Valves, Check Valves, Air Governors, Needle Valves, Hose Assemblies and Couplings.

25 YEARS OF HELPING AIR POWER SERVE INDUSTRY BETTER

CMH FLEXIBLE METAL HOSE

cuts maintenance ...helps keep dryer temperatures constant on this paper machine



By replacing rigid pipe connections to the dryer cylinders of this paper machine with sections of CMH Flexible Metal Hose it was possible to reduce maintenance and minimize paper spoilage due to improper drying. In the rigid pipe hook-up, vibration in the machine caused early failure of the packing in the rotary joint. Steam loss through the damaged packing and its attendant temperature drop resulted in insufficient drying, necessitating the discarding of this paper. CMH REX-WELD corrugated, braid-covered, bronze hose installed as steam inlet and condensate return connections to the rotary joint absorb the vibration and end this damage to packing. In addition, the flexible metal hose corrects for misalignment, takes any normal motion in the system and absorbs thermal expansion and contraction.

Designers can forestall operating complaints of this type, by designing CMH Flexible Metal Hose into their products or by specifying the use of CMH Flexible Metal Hose. In all connections subject to vibration, misalignment, flexation, or expansion and contraction the motion can be absorbed by CMH Flexible Metal Hose. There is a size and type to meet every need. Write for complete information and descriptive literature.

Flexon identifies CMH products that have served industry for over 49 years.

CHICAGO METAL HOSE Corporation

1351 S. Third Ave. • Maywood, Ill. • Plants at Maywood, Elgin, Rock Falls, and Savanna, Ill.
In Canada: Canadian Metal Hose Co., Ltd., Brampton, Ont.

CMH

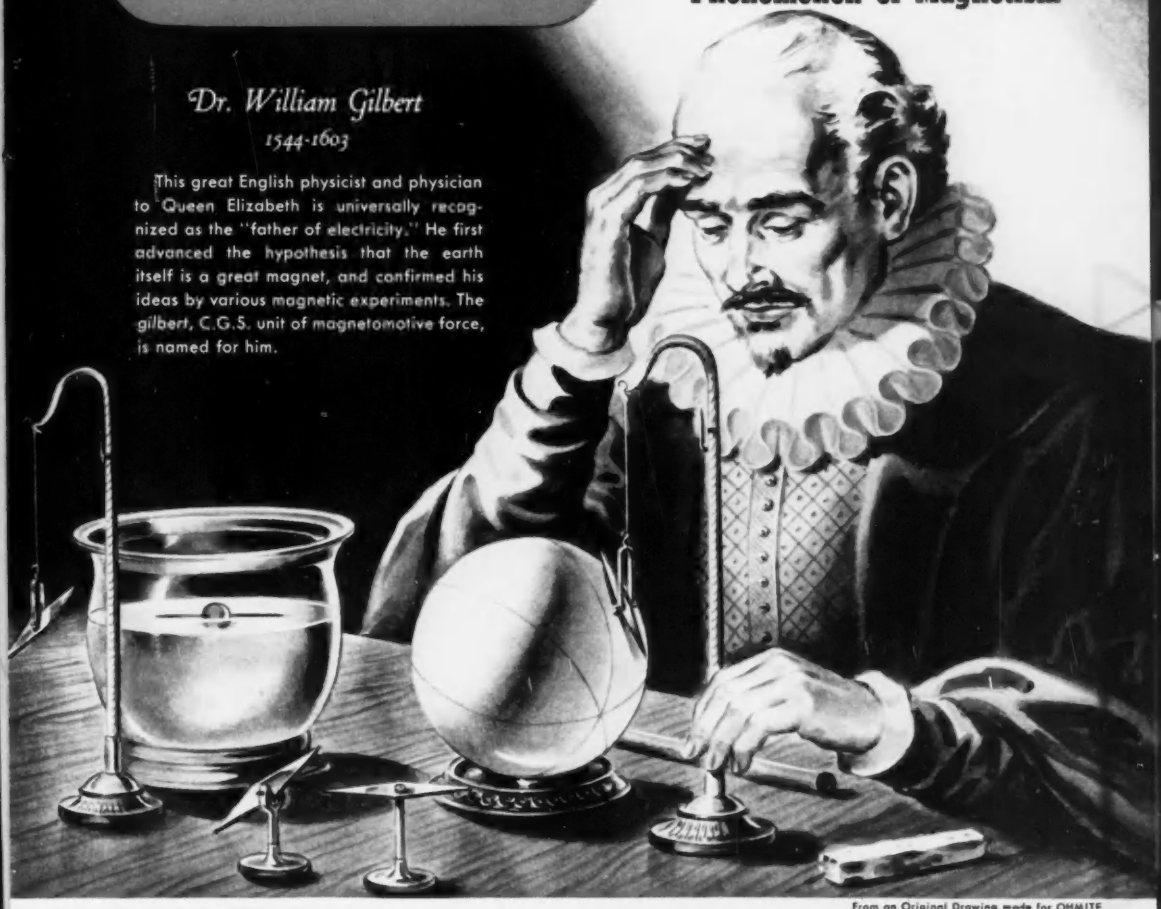
ONE DEPENDABLE SOURCE
for every flexible metal hose requirement

Convoluted and Corrugated Flexible Metal Hose in a Variety of Metals • Expansion Joints for Piping Systems
Stainless Steel and Brass Bellows • Flexible Metal Conduit and Armor • Assemblies of These Components

GILBERT ...FIRST to investigate the Phenomenon of Magnetism

Dr. William Gilbert
1544-1603

This great English physicist and physician to Queen Elizabeth is universally recognized as the "father of electricity." He first advanced the hypothesis that the earth itself is a great magnet, and confirmed his ideas by various magnetic experiments. The *gilbert*, C.G.S. unit of magnetomotive force, is named for him.

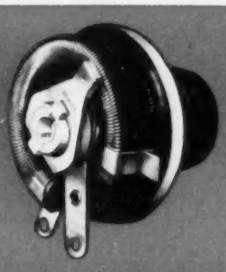


From an Original Drawing made for OHMITE

OHMITE® ...FIRST in Rheostats ...today

Be Right with

OHMITE
RHEOSTATS
RESISTORS
TAP SWITCHES



More manufacturers have standardized on Ohmite rheostats for their products . . . more companies are buying Ohmite rheostats for their own use . . . than any other make of rheostat on the market, today. The primary reason for this industry-wide preference for Ohmite rheostats is their proven dependability . . . their ability to give *extra* years of unfailing, trouble-free service.

OHMITE *Rheostats...*

Dependable

because they're built that way!

METAL-GRAPHITE BRUSH

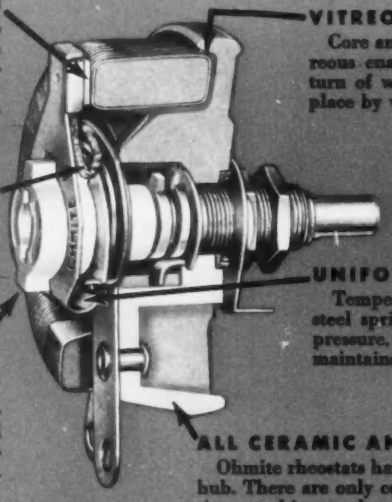
Perfect contact with negligible wear on the wire is insured by the metal-graphite contact brush (varied to fit the current and resistance) and the large, flat contact surface.

LARGE PIGTAIL SHUNT

Current is carried directly to the slip-ring by a pigtail shunt of ample size, assuring an uninterrupted connection at all times. Large slip-ring minimizes mechanical wear.

INSULATED SHAFT

High strength ceramic hub insulates the shaft and bushing from all live parts. Underwriters' Laboratories listed models are available.



VITREOUS ENAMEL BOND

Core and base are bonded together by vitreous enamel into one integral unit. Each turn of wire is also permanently locked in place by vitreous enamel.

UNIFORM CONTACT PRESSURE

Tempered steel contact arm forms a long steel spring which assures uniform contact pressure. Universal joint action of the brush maintains "flush-floating" contact.

ALL CERAMIC AND METAL CONSTRUCTION

Ohmite rheostats have a ceramic core, base, and driving hub. There are only ceramic and metal in their construction—nothing to char, burn, shrink, or deteriorate. They are designed for long, trouble-free life.

OHMITE MANUFACTURING COMPANY
4835 Flournoy Street, Chicago 44, Illinois

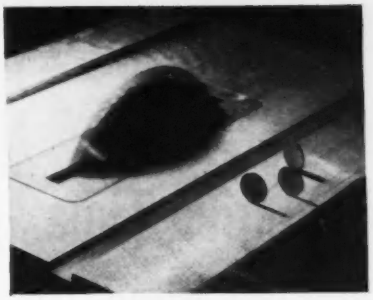
WRITE on company letterhead for Catalog and Engineering Manual No. 40.

Be Right with...

OHMITE®

RHEOSTATS · RESISTORS

TAP SWITCHES



FOUR star performers in a "ONE TOOL WORKSHOP"

Here's visual evidence of the Star Performers' worth to the SHOPSMITH . . . an amazingly accurate, versatile, low-priced electric power tool for hobbyists, maintenance departments, and small businesses. With saw blade at full speed, coins stand on edge . . . a tribute not only to the precision construction of the machine, but to the performance of Fafnir Ball Bearings.

Since the SHOPSMITH operates in both vertical and horizontal position and under so many different conditions, the Fafnir head-stock ball bearings are an extremely important factor to successful operation.

Putting accuracy into inexpensive equipment is a problem that Fafnir has solved successfully on many occasions. That's because Fafnir's experience is not limited to just one or two industries but is industry wide. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR

BALL BEARINGS

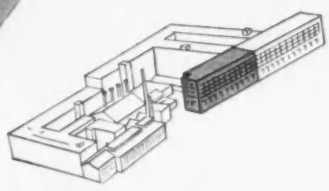
MOST COMPLETE LINE IN AMERICA

BEARINGS SHOWN

The Shopsmith spindle floats on four Fafnir pre-lubricated Mechani-Seal Type Ball Bearings. Two support the spindle in the quill, and two support the internally splined drive shaft.

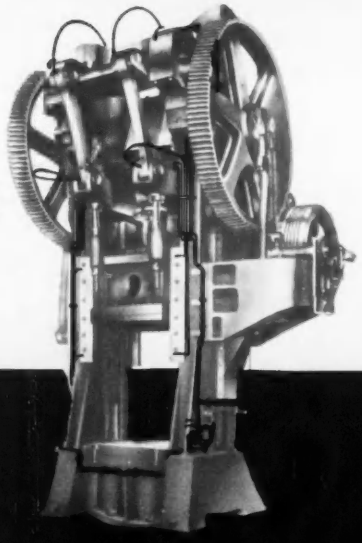
★ PROGRESS REPORT

NEW PLANT ADDITION!



Part of a long range expansion program . . . the recently completed, 6-story modern building located at the main Fafnir Plant comes at an opportune time. It adds 70,000 square feet of manufacturing space to the 750,000 previously occupied by 3 Fafnir plants . . . now, almost 19 acres.

How To Design Extra Production Time into Every Machine



ALEMITE Accumeter automatic lubrication

reduces maintenance, increases machine output

You add extra production time to your machines by removing the need to shut down for lubrication . . . when you *design in* Alemite Accumeter Automatic Lubrication! Consisting of a lubricant pump, a distribution system of tubing, and *force-feed* valves for individual bearings—an Accumeter System makes lubrication foolproof. It automatically lubricates every bearing on a machine . . . from one central point . . . *while production continues*. Ends the risks of errors or neglect by your customers. Assures greater production, lower maintenance costs, longer machine life!

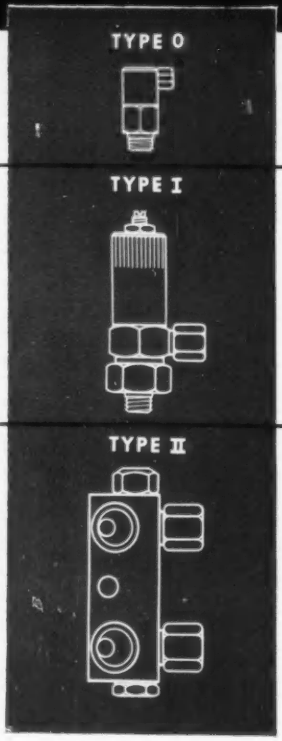
No other method has equaled Alemite's Accumeter Systems for sustained accuracy in metering oil or grease to bearings. Tests show *no variation* in the amount of lubricant discharged to bearings . . . even after 73,312 lubrication cycles, equal to 122 years of twice-a-day service! Moreover, lubrication is either fully hydraulic or continuous between cycles, thanks to the exclusive Alemite "accumulating" feature that *prolongs* the discharge of lubricant to bearings!

To cover your full range of requirements, there are three different Alemite Accumeter Automatic Lubrication Systems. Versatile in application, they are adaptable to virtually any machine. Send now for free bulletin giving full data. Alemite, Dept. T-71, 1850 Diversey Pkwy., Chicago 14, Illinois.

MIDGET OIL VALVES
Fixed output metering valves for single line system serving up to 200 small bearings. Especially suited to precision machines, and wherever space is limited.

ONE-BEARING VALVES
Oil or grease metering valves, with *fixed or adjustable output*, for single line system. Valves for any bearing capacity. Single system serves up to 400 bearings.

TWO-BEARING VALVES
Adjustable output metering valves for oil or grease. Each serves 2 bearings. Valves fully sealed, hydraulically operated on both load and discharge cycles. System handles up to 600 bearings. Manual or automatic operation.



ALEMITE

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Another Product of STEWART WARNER

DELCO MOTORS

the best *running mate* your product can have!

REFRIGERATORS

WASHING MACHINES

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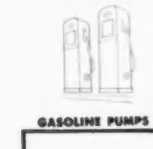
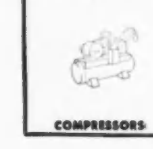
FURNACE BLOWERS

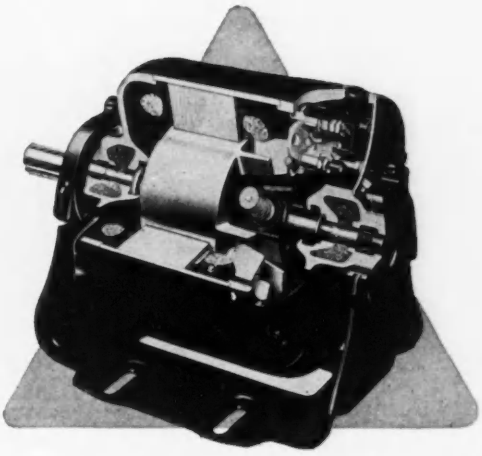
OIL BURNERS

STOKERS

WATER PUMPS


GASOLINE PUMPS


COMPRESSORS



- Rugged cast iron end frames
- Wool-packed, cored oil wells
- Rigid steel frame
- Positive-action switch
- Steel-backed babbitt bearings
- Quiet operation
- Die-cast Rotor

To give the most dependable service, appliances need the most dependable motors. Delco has the engineering and manufacturing experience that assures appliance motors of lasting quality.

But, just as important to manufacturers today is flexibility of supply. In fast-changing markets, quick changes in motor specifications or delivery dates are often called for. Delco meets these requirements, too—with an organization set up to deliver what's wanted when it's wanted.

It is easy to understand why more and more manufacturers are turning to Delco—the best running mate your product can have.

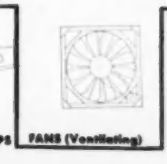
DELCO DAYTON OHIO

DELCO MOTORS

DELCO PRODUCTS
Division of General Motors Corporation, Dayton, Ohio

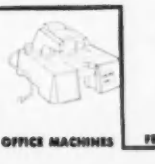
SALES OFFICES: Chicago • Cincinnati • Cleveland • Dallas • Detroit • Hartford • Philadelphia • St. Louis

HOME WORK SHOPS


FANS (Ventilating)

DISHWASHERS

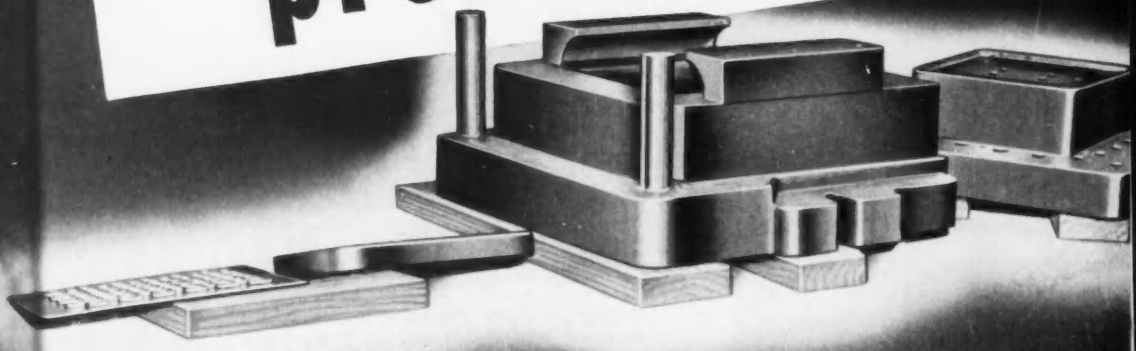
IRONERS


OFFICE MACHINES

FEED GRINDERS

SEPARATORS

500% more production



STEWART-WARNER CO.
Indianapolis, Indiana

MATERIAL DRAWN	Grade of Inconel used — Type AN-QQ-N-271, 16 gage Condition A, Commercial Soft. Type press — No. 8 Consolidated with air cushion. Speed of press — 25 strokes per minute.
ORIGINAL DIE	Original construction of die — Sectional punch of high carbon, high chrome, tool steel, hardened and ground. Form blocks for wiping up the sides were inserts of high carbon, high chrome, hardened and ground, with draw radii polished. These were mounted in cast iron retaining block.
ORIGINAL PRODUCTION	Location of parts — parts are located on pins mounted in air operated pressure pads. Results of operation prior to change—due to inconsistency in application of drawing compound, metal pickup on the draw radii caused the corner holes to become elongated and form oversize. Inserts had to be replaced after 2,000 pieces due to wear. The die required polish on the draw radii every 50 to 100 parts formed.
NEW AMPCO DIE	Change to Ampco — A grade 24 Ampco solid casting, 2 inches thick was inserted in the same cast iron retaining block and machined to form dimensions. Draw radii were polished.

RESULTS OF CHANGE — Greatly increased production — "Over 10,000 parts have been formed over this insert. No polishing of the draw radii has been required and the insert shows little indication of wear."

IT'S PRODUCTION-WISE TO AMPCO-IZE!

Gear blank — Centrifugally-cast of Ampco Metal. Note contours on ID.

Pump diffuser — Cast of Ampco Metal.

Meter housings and fluid ends — Sand-cast of Ampco Metal.

Gears — Centrifugally-cast Ampco Metal.

Bushings — Centrifugally-cast Ampco Grade 18 standard bars.

---with AMPCO* METAL

The savings effected by the greatly increased production reported on the opposite page are typical of results obtained when long-wearing Ampco Metal is correctly applied. Wear-resistance, compressive strength, high impact and fatigue values, excellent bearing qualities, corrosion resistance — all these are cost-saving properties that make Ampco aluminum bronze alloys ideal for longer life and reduced downtime in many applications. Only a few can be shown here. Consult your nearest Ampco field engineer, or write for complete details.

*Reg. U. S. Pat. Off., Ampco Metal, Inc.

Tear out this coupon and mail today!

Ampco Metal, Inc.
Milwaukee 46, Wisconsin
West Coast Plant
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AMPCO METAL, INC., Dept. PE-7, Milwaukee 46, Wisconsin

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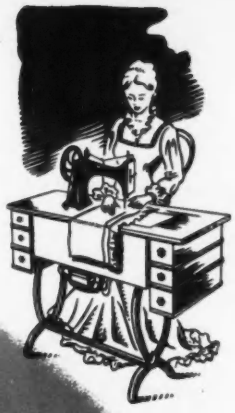
City..... (.....) State.....

D-2

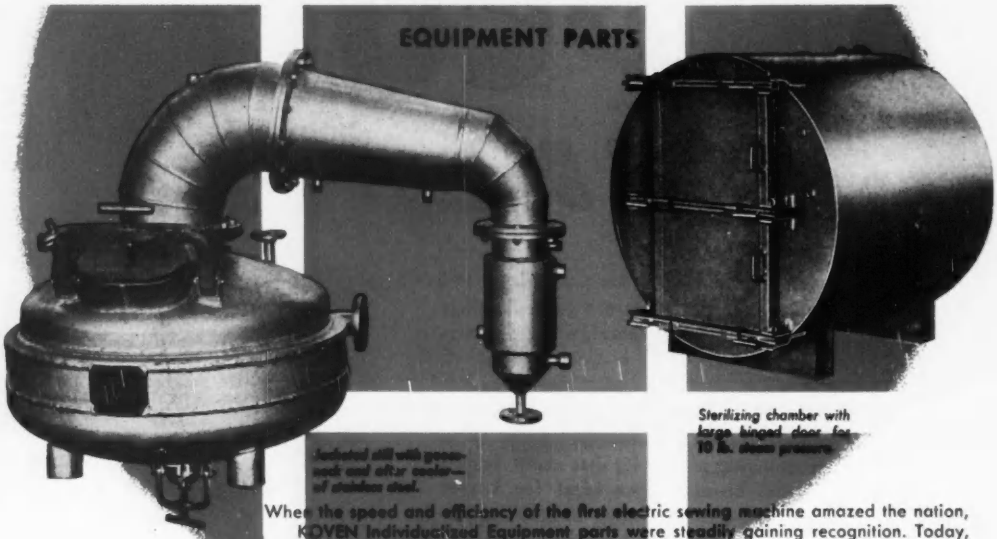
BACK IN THE 1880's



WHEN SINGER INVENTED THE FIRST ELECTRIC SEWING MACHINE

Koven

WAS MAKING INDIVIDUALIZED EQUIPMENT PARTS



Jacketed still with gooseneck and after cooler of stainless steel.

Sterilizing chamber with large hinged door for 10 lb. steam pressure.

When the speed and efficiency of the first electric sewing machine amazed the nation, KOVEN Individualized Equipment parts were steadily gaining recognition. Today, leading equipment manufacturers are realizing greater profits through the use of precision parts individually designed and made for them by KOVEN. Because our two huge plants and highly trained personnel are especially equipped, we can fabricate equipment parts tailored to your individual needs faster and often at much less cost than they can be produced in your own plant. Call or write today for a consultation with a KOVEN representative—no obligation.

Our complete modern facilities include: machine, welding, plate and sheet metal, galvanizing and painting shops. X-ray equipment insures quality control in every KOVEN Individualized Equipment part.

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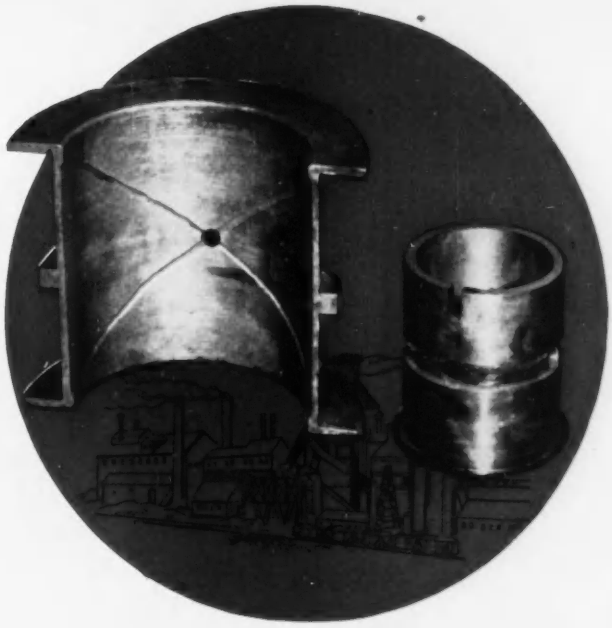
Plants: Jersey City, N. J.

Dover, N. J

KOVEN FOR INDIVIDUALIZED EQUIPMENT PARTS SINCE 1881



PRODUCED: BEARINGS THAT LAST 3 TIMES LONGER

An example showing how National Bearing Division has helped lick costly maintenance problems

AIR that's laden with dust and scale can be rough on bearings—as a large Midwest steel plant found out with an average of just 2 months' service on bearings in charging car wheels and edgers. Replacement labor and expense were going way out of line, when National Bearing Division stepped into the picture.

Our engineers made a special study of this mill's problem. As a result of this study they recommended a hydraulic bronze, both for its superior anti-frictional qualities and its high abrasion-resistance. Special methods of alloying and pouring, developed through N-B-M metallurgical research, insured sounder and denser castings of this bronze—further increasing its resistance to wear and abrasion.

Result? These bearings last 3 times as long as the bronze formerly used! Replacement labor and expense took a nosedive.

This actual example of how National Bearing Division saved money for a customer proves two important points: *first*, that N-B-M has the facilities for thorough research on proper alloying, and *second*, that we have the engineering skill to apply the fruits of this research to our customer's problems on . .

Non-Ferrous Bearings and Castings—
As-Cast or Machined

Bronze Bars—
As-Cast or Machined; Cored, Solid, Hexagon

Babbitt Metals—
For every type of bearing service

AMERICAN Brake Shoe COMPANY

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4932 Manchester Avenue • St. Louis 10, Mo.

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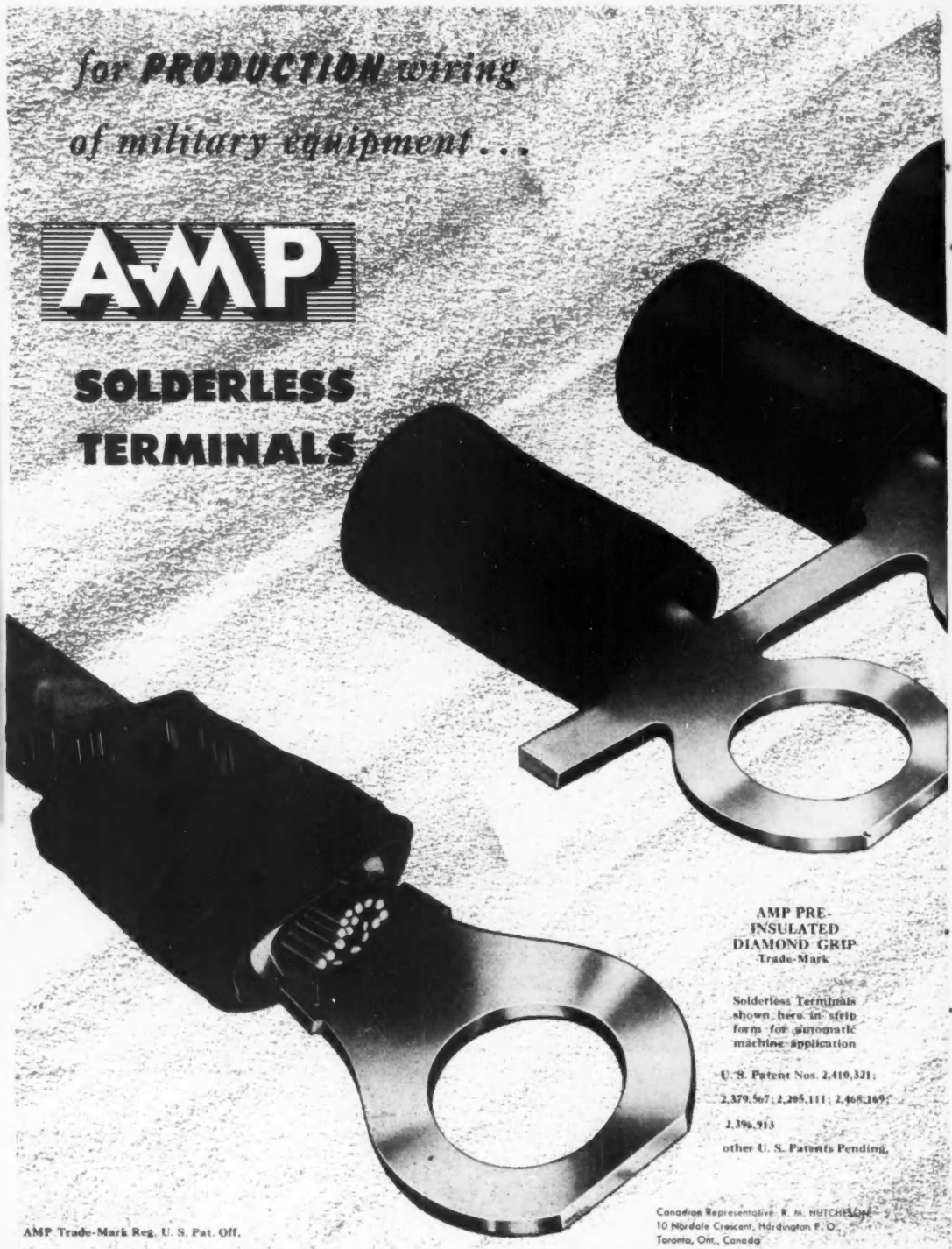
for ***PRODUCTION*** *wiring*

of military equipment . . .

AMP

SOLDERLESS TERMINALS



AMP PRE-INSULATED DIAMOND GRIP Trade-Mark

Solderless Terminals shown here in strip form for automatic machine application

U. S. Patent Nos. 2,410,321; 2,379,567; 2,205,111; 2,468,169; 2,396,913

other U. S. Patents Pending.

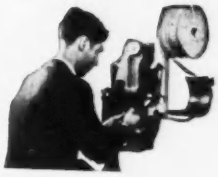
AMP Trade-Mark Reg. U. S. Pat. Off.

Canadian Representative: R. M. HUTCHESON
10 Nordale Crescent, Hardington P. O.
Toronto, Ont., Canada

NEW SPEED QUALITY UNIFORMITY

UP TO 4,000 COMPLETE, INSULATED CONNECTIONS PER HOUR WITH HIGH SPEED AMP AUTOMATIC MACHINES

Lowest installed costs and highest application speeds in industry are obtained through use of AMP AUTO-CRIMP strip terminals in special AMP air or electric machines. Each machine cycle produces a strong, uniform, completely insulated connection. NO CAPITAL INVESTMENT INVOLVED! *These seconds are suitable for the most critical of applications.*



SUPERIOR DESIGN, PRODUCTION, AND PERFORMANCE TOLERANCES

Critical crimping dimensions are not lost in manufacture of tool or terminal. This applies throughout wide range of hand, foot, pneumatic or automatic tools. Here are crimping devices suitable for every type of job at every production level!

AMP **AIRCRAFT-MARINE PRODUCTS INC.**

2100 Paxton Street, Harrisburg, Pa.

PRECISION COMES IN ANY SIZE FARREL® GEAR

from ¼ inch to 20 feet in diameter

Farrel herringbone gears are made in a complete range of sizes from ¼ inch to 20 feet diameter, ¼ to 60 inch face, 24 DP to 0.75 DP, for any power capacity and any application. The quiet, vibration-free performance and long life you can expect from these gears result from extreme accuracy of tooth spacing, contour and helix angle . . . qualities inherent in the Farrel-Sykes method of gear generation.

Straight tooth (spur) gears and single helical gears are supplied in any size from ¼ inch to 20 feet diameter, ¼ to 30 inch face, 24 DP to 0.5 DP. Also available are large internal gears, with either spur or helical teeth, in sizes up to 16 feet diameter, 12 inch face, 1¼ DP.

Farrel engineers will be glad to assist you in working out unusual gear problems. Information about Farrel precision herringbone gears, or any of the other types mentioned on this page, will be sent on request.

FARREL-BIRMINGHAM COMPANY, INC., ANSONIA CONNECTICUT

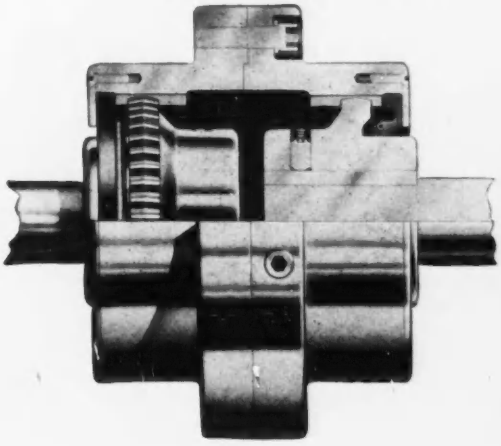
Plants: Ansonia and Derby, Conn., Buffalo, N. Y. Sales Offices: Ansonia, Buffalo, New York, Boston, Pittsburgh, Akron, Cleveland, Detroit, Chicago, Portland (Oregon), Los Angeles, Salt Lake City, Tulsa, Houston, New Orleans

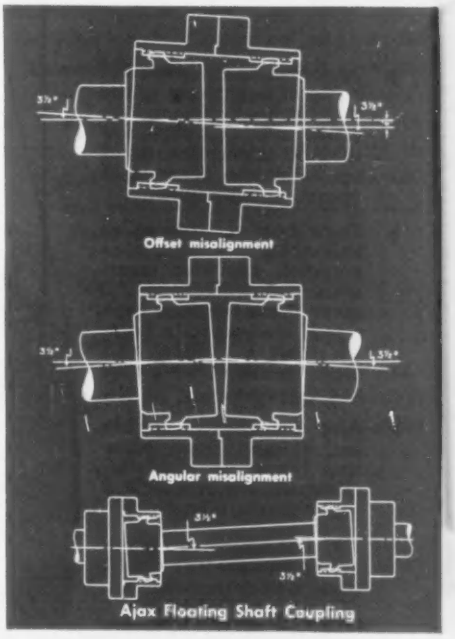
Farrel-Birmingham®

FB-672

EVERY MAN WHO HAS MISALIGNMENT TROUBLES WELCOMES THIS SENSATIONAL NEW

AJAX DIHEDRAL COUPLING





● Ajax Dihedral Couplings eliminate misalignment problems. They simplify machine design and cut installation time.

New and exclusive Ajax tooth shape provides for maximum misalignment up to 7° with tooth clearance (backlash) kept to oil film requirements. Long life is assured because more tooth contact is maintained under operating conditions than with any other shaped tooth. 30 degree involute splines provide strong basic tooth form.

Positive oil seals keep lubrication in and dirt out.

If you use couplings, *write for new Bulletin 50.*

THE GEAR TYPE COUPLING THAT HANDLES MISALIGNMENT HERETOFORE CONSIDERED EXCESSIVE

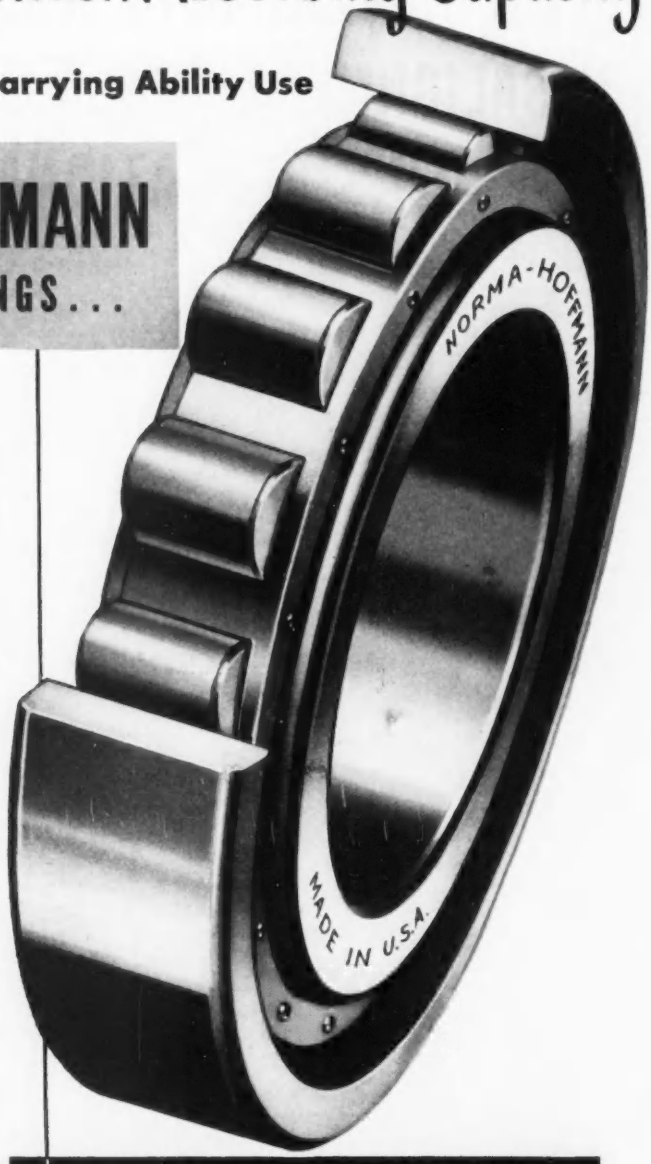
AJAX FLEXIBLE COUPLING CO. INC.

WESTFIELD, NEW YORK

For Highest Shock Absorbing Capacity

and Greatest Load Carrying Ability Use

NORMA-HOFFMANN
ROLLER BEARINGS...



- Performance records in all types of equipment prove that Norma-Hoffmann Precision Roller Bearings have the built-in stamina to stand up under the severest of operating conditions.
- Their short, accurate roller and cylindrical race construction provides maximum load contact area . . . gives these bearings high steady load capacity, large overload capacity, and high resistance to shock and vibration.
- Also available in double and single lipped outer ring types. All are interchangeable with standard single row ball bearings.
- Whether your bearing requirements are for original equipment or replacement, these precision-built Norma-Hoffmann Roller Bearings will give you outstanding performance under the most critical severe conditions of speed, load, shock, and vibration.
- Write for information and engineering assistance.

NORMA-HOFFMANN
***Precision* BEARINGS**
BALL • ROLLER • THRUST

NORMA-HOFFMANN BEARINGS CORPORATION,
STAMFORD, CONNECTICUT
FIELD OFFICES: Chicago, Cleveland, Detroit, Dallas, Cincinnati, Los Angeles, San Francisco, Seattle

"EMERGENCIES" DON'T LAST FOREVER

WILL YOUR PRODUCTS FOR THE FUTURE BE READY AT THE RIGHT TIME?

TYPICAL EXAMPLES OF STAMPINGS WE MAKE FOR HUNDREDS OF COMPANIES

Commercial Fruit Juicer
Tub and Cover for Portable Dishwasher
Base for Power Lawn Mower
Street Light Shade
Safety Guard for Power Tools
Auto Oil Pan

Now is the time to make plans for tomorrow's products. While new or redesigned products must be temporarily shelved because of shortages, the time is ripe for plans and development work.

And may we make this suggestion. Don't let your product planning stop at the drawing board stage. Instead of filing these ideas, send them to G. P. & F. Perhaps we can offer suggestions for production economies. Then let us give you an estimate for tools and unit costs *and, if they are okay, let us build the tools.*

Then you are really ready when the "green light" comes. *Months of precious time will be saved when it really counts.* You'll be in production—jumping the gun over others who are scrambling for ideas and sales.

WRITE FOR FREE BOOK

"Science and Skill in Sheet Metals." It illustrates many jobs produced for G. P. & F. customers . . . gives complete data on our facilities.

STAMPING • DRAWING
FORMING • TINNING
GALVANIZING • WELDING
VITREOUS ENAMELING
SPRAY FINISHING
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Metal Fabricating and Finishing has been our business since 1880

19 Acres of Production Facilities . . . Complete Tool and Die Department

G.P.&F. CONTRACT DIVISION MILWAUKEE

GEUDER, PAESCHKE & FREY CO.

1505 W. St. Paul Ave.
MILWAUKEE 1, WISCONSIN

While you are planning for tomorrow, let us produce for you today. Sub-contract the metal stampings needed on your Defense Orders. Send blueprints to G. P. & F. for prompt quotations.

Built to Last

"How Long Will It Last?" This question can be one of the most important points by which your product is judged. Further, the motor which you choose may be the determining factor.

Emerson-Electric Motors are *built* to last. Sound engineering and design principles, plus rugged construction have helped to build a reputation for long life into numerous nationally known products. These characteristics have also made them the standard for quiet, efficient, uniform power.

The wide acceptance of Emerson-Electric Motors by domestic, institutional and industrial consumers is based on a background of 60 years' experience. It's sales assurance to select motors with *lasting power.* Your inquiry is invited on this complete line of motors in the 1/20 to 5 h.p. range.

Write for these Emerson-Electric Motor Data Bulletins

Appliance and equipment manufacturers, with applications for motors of 1/20 to 5 h.p., can profitably use these reference guides. Specifications, construction and performance data are included for these motors:

- ☐ 140-A Capacitor-Start
- ☐ 140-B Split-Phase
- ☐ 140-C Integral
- ☐ 140-D Fan-Duty
- ☐ 140-E Oil-Burner
- ☐ 140-F Jet Pump
- ☐ 140-G Blower

The Emerson Electric Mfg. Co.
St. Louis 21, Mo.

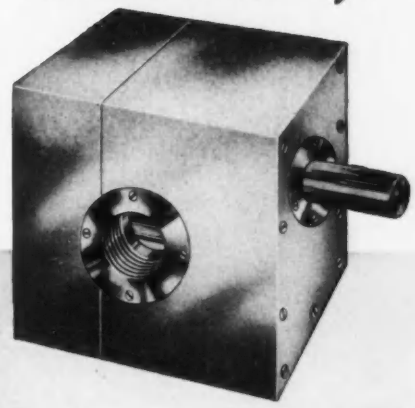
EMERSON ELECTRIC
MOTORS • FANS APPLIANCES

Introducing Series III OBERDORFER INTERNATIONAL

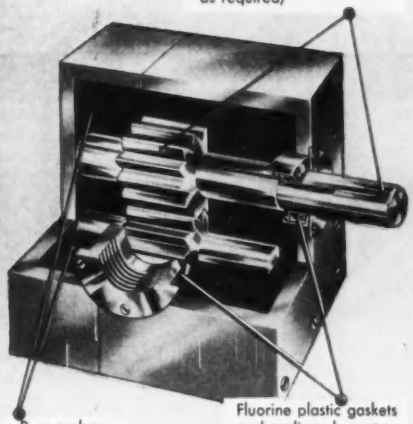
Chemically Inert N^X CARBON BLOCK

ROTARY GEAR PUMPS

Patents applied for



High nickel stainless steel gears, shafts and fittings (or other metals or plastics as required)



Pure carbon pump housing

Fluorine plastic gaskets and sealing elements

After five years of experimentation we offer industry a new line of rotary gear pumps specifically unlimited in their ability to withstand the destructive action of an exceedingly wide range of liquids known as critically corrosive prior to this development.

Constant materials of construction

1. The entire pump housing is a machined block of pure carbon.
2. The gaskets and sealing elements are composed of a fluorine plastic.

Variable materials of construction

1. Standard N^X International Series III Pumps are equipped with high nickel stainless steel gears, shafts and fittings.
2. These gears, shafts and fittings may be fabricated of a variety of metals and plastics including copper, bronze, aluminum, nickel, steel, nylon, etc. depending upon the requirement of the liquid being pumped.

CAPACITY TABLES — Gallons of Water Per Hour for Series III OBERDORFER INTERNATIONAL PUMPS Outlet Pressure—P.S.I. (Pounds per square inch)

1725 R.P.M. (Standard Electric Motor Speed)

Pump Size	2 lbs.	20 lbs.	40 lbs.	60 lbs.	80 lbs.	100 lbs.
$N^X1\frac{1}{2}$	126	115	105	98	93	90
N^X2	245	225	215	205	195	190
N^X3	445	425	405	390	380	370
N^X4	640	610	580	550	530	510
N^X7	1185	1160	1140	1120	1100	1085
N^X9	1400	1375	1350	1325	1300	1280

PRICE LIST [Approximate] – N^X Pump Only
(Motor and base price upon application)

$N^X1\frac{1}{2}$	N^X2	N^X3	N^X4	N^X7	N^X9
$65.00	$75.00	$100.00	$110.00	$135.00	$150.00

CUBICAL DIMENSIONS [Approximate]

Pump No.	Height	Width	Depth
$N^X1\frac{1}{2}$ and N^X2	5 "	$3\frac{1}{2}$"	$4\frac{1}{4}$"
N^X3 and N^X4	5 "	$3\frac{1}{2}$"	$4\frac{3}{4}$"
N^X7 and N^X9	$6\frac{1}{2}$"	$4\frac{1}{2}$"	$5\frac{1}{2}$"

1951 Capacity Series III Pumps – 50,000

Write Dept. PE 517

CHEMICAL PUMP DIVISION
Oberdorfer Foundries, Inc.
Syracuse, N. Y.

Important Notice

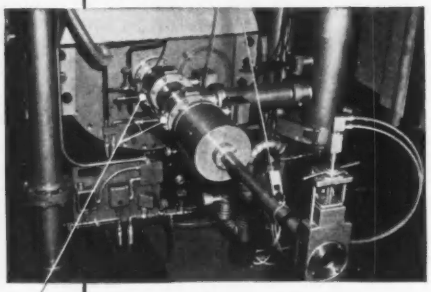
At no cost we now make available to industry 500 No. $N^X1\frac{1}{2}$ motor driven pump units for the purpose of operating breakdown tests *to prove the materials of construction of our entire line* of N^X International Rotary Gear Pumps.

A D.O. will be necessary, important enough to replace the electric motor, rotary seals, carbon blocks and nickel steels.

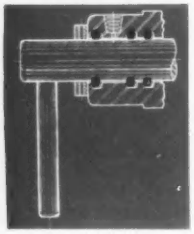
A brief description of your pumping problem will assist us in predicting the outcome of your test.

These pumps are available at present only at our factory. Write for details and O.E.M. discounts.

fewer
headaches,
dependable
performance



...with



LINEAR
PRECISION MOLDED
"O"
RINGS

The Van de Graaff Electron Accelerator, a product of High Voltage Engineering Corporation, utilizes the dependable performance of LINEAR "O" Rings in its vacuum systems.

Typical is their incorporation in the gate valves, shown above, where they have permitted a more straightforward design . . . resulting in simplified construction and operation. The detail drawing shows the manner in which they provide positive vacuum seal under continuous use.

LINEAR "O" Rings are compounded of natural or synthetic rubber, fluorethylene polymers, and "Silastics" . . . are molded in a complete range of J.I.C. and A.N. standard sizes, as well as hundreds of non-standard sizes for special uses. Produced under rigid supervision and held to the closest of tolerances, LINEAR "O" Rings can be depended upon for continuous and lasting service . . . mighty important in these days of critical material shortages.

For easier installation and reduced maintenance, it will pay you to consult LINEAR during the design stages of your sealing applications.

"PERFECTLY ENGINEERED PACKINGS"
LINEAR
LINEAR, Inc., STATE ROAD & LEVICK ST., PHILADELPHIA 35, PA.

Leach
RELAYS

Precision is the Keynote—in Production and Performance

The word precision perfectly characterizes every relay manufactured by LEACH, and this precision is most apparent in their performance. Whatever the purpose, LEACH can provide relays of advanced design for flexibility, economy and unexcelled performance. Highest standards of engineering, materials and workmanship.
For better controls through better relays—contact LEACH.

LEACH RELAY CO.
5915 AVALON BOULEVARD, LOS ANGELES 3, CALIF.
Representatives in Principal Cities of U. S. and Canada

KOH-I-NOOR PRODUCTS

The RIGHT pencil for the RIGHT job

62 Years Ago KOH-I-NOOR made the FIRST Drawing Pencil . . . in 17 DEGREES, 6B to 9H. Since that time no other pencils have approached Koh-I-Noor's Record for Unfailing Uniform Performance.

No Matter What Your Requirements . . .
you will find a KOH-I-NOOR Product to satisfy you completely

NOW Available . . .
#1600 KOH-I-NOOR Polycolor Pencils with IMPORTED Leads
in 67 colors

DRAWING PENCILS
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COLORED PENCILS
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KOH-I-NOOR

KOH-I-NOOR PENCIL COMPANY, INC. BLOOMSBURY, NEW JERSEY

Six manufacturing plants, each specializing within a specific range of alloys and sizes, produce millions of pieces each month. Quality control to meet your manufacturing standards.

FEDERAL-MOGUL CORPORATION

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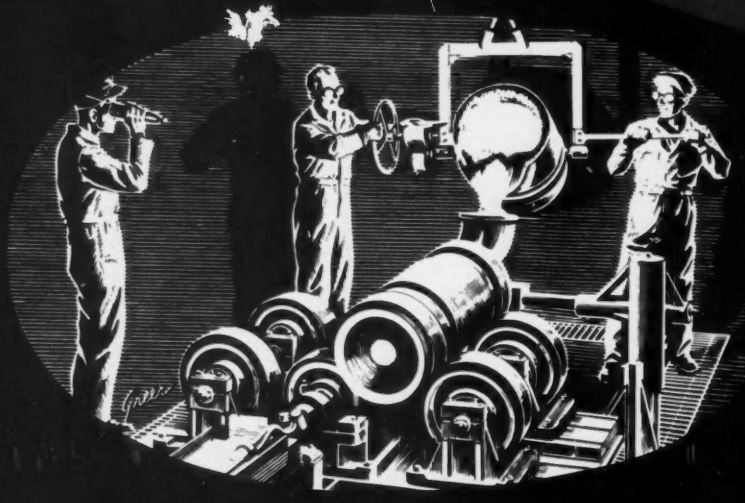
FREE! *Your business letterhead request brings "Sleeve Bearing Topics"—the engineering bulletin that keeps you current on bearing developments. Write today, while complete back file is available.*

FEDERAL-MOGUL *Since 1899*

family



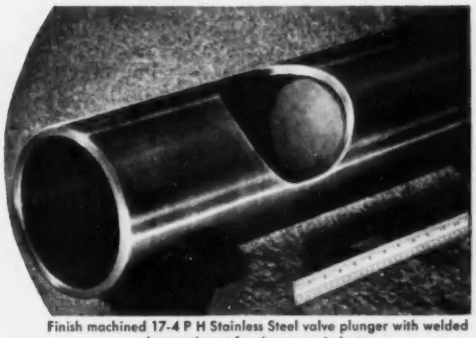
SPECIAL PRODUCTS DIVISION

U. S. PIPE AND FOUNDRY CO., BURLINGTON, NEW JERSEY

AMERICA'S LARGEST PRODUCER OF CENTRIFUGALLY CAST FERROUS METAL PRODUCTS IN TUBULAR FORM

portrait!

METAL MOLD CENTRIFUGAL CASTING SPELLS ECONOMY AND EFFICIENCY FOR WIDENING GROUP OF STAINLESS STEEL PRODUCTS



Finish machined 17-4 P H Stainless Steel valve plunger with welded plate and port for the paper industry.

Type 303 Stainless Steel stock from which rings and sleeves are fabricated for many industrial and defense applications.

Rough machined Type 316 Stainless Steel bowl casting for the food and processing industries.

Pictured here are a few of the many stainless steel products now included in the rapidly increasing family of products centrifugally cast for industry by our new metal mold process.

This method offers many specific advantages. For one, centrifugally cast stainless steel cylindrical sections, formed by pouring molten metal into rapidly spinning, refractory-coated permanent metal molds represent the ultimate in casting quality, imparting a fine, dense grain structure, unusually free from conventional casting defects.

You may find that your stainless steel product can be cast more advantageously by this versatile process. Our engineers will be glad to answer any of your questions.

SIZE RANGE AND COMPOSITION FLEXIBILITY

Outside Diameter—4" to 30"

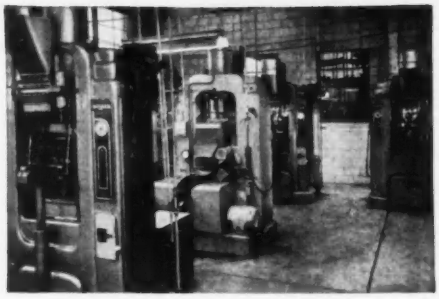
Wall Thickness—$\frac{1}{8}$" and up

Length—Up to 14' in the "as-cast" condition

Types of Stainless Cast—All standard AISI and ACI grades of ferritic and austenitic stainless, plus "Special" types

CHECK THESE ADVANTAGES FOR YOUR CYLINDRICALLY-SHAPED PRODUCTS:

- Reduced Processing Time and Increased Production.
- Minimum Scrap Loss.
- Design of parts to suit the specific job requirement by selecting the correct alloy – not the next best available alternate.
- Conservation of critical metals and alloys – especially on tubular parts now produced from solid sections.



Automatic Molding cuts costs for Electric Steam Radiator

These fully automatic molding presses have operated 24 hours a day ever since they were installed. The only work required is filling hoppers and removing finished parts.

New production figures of the Electresteem vaporizer and the Baby Chef Jr. bottle warmer are gratifying to both executive and shop levels of Electric Steam Radiator Corporation, Paris, Ky.

In the re-designed form—plastics replacing porcelain—the product is generally superior: more durable, lighter, easier to handle, and with less external heat loss.

If you want to know what automatic molding can save you in production costs, send parts or blueprints for a free analysis and report by Stokes engineers.

STOKES MAKES Automatic and Semi-Automatic Molding Presses, Plunger Presses, Closure Presses, Preforming Presses, Industrial Tabletting and Powder Metal Presses, Vacuum and Special Processing Equipment, Water Stills and Special Machinery.

STOKES

F. J. STOKES MACHINE COMPANY, 5900 TABOR ROAD, PHILADELPHIA 20, PA.

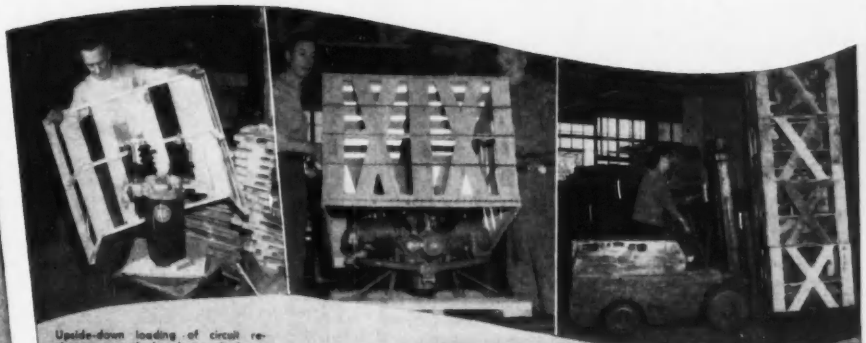
Now, more than ever before...

YOU NEED THE PROTECTION OF

WIREBOUND BOXES and CRATES

Losses due to container failure have no place in an industrial economy facing material allocations and shortages. That's why you should investigate *Wirebounds* —which combine the strength of steel with thinner wood to bring you *better product protection at lower cost.* Three hundred graduate engineers of the Wirebound Institute have been technically trained to design tailor-made *Wirebounds* which assure damage-free product delivery. The value of this container engineering is clearly demonstrated in the following case histories. We will be glad to show you how these benefits apply to *your* product. Use the coupon below.

YOU CAN CUT DAMAGE CLAIMS LIKE THIS:



Upside-down loading of circuit reclosers caused breakage, leakage, sometimes irreparable damage in handling and transit. Since switching to Wirebounds, company reports damage claims have become negligible.

Using Wirebounds designed to "float" 400 lb. precision engines, this manufacturer chalked up a record of 3000 shipments in fifteen months without a single instance of damage in transit due to container failure.

Flexible power saw maker reduced shipping weight from 820 to 775 pounds, cut crating time 30%. Company stacks and handles units four high. Shipping damage due to container failure has been completely eliminated.

choose your course of action...

Wirebound
BOXES & CRATES

☐ Send me general information . . . complete descriptive book titled "What to Expect from Wirebounds."

☐ Send me specific information . . . tear sheets of case histories of packing products similar to mine.

☐ Give me direct action send an Institute trained sales engineer to show the advantages of Wirebound packing for my own product.

NAME POSITION

FIRM

STREET AND NUMBER

CITY ZONE STATE

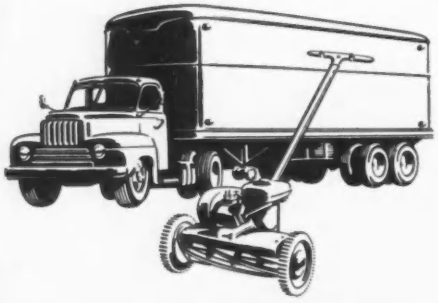
OUR PRODUCT IS IT WEIGHS

mail now to WIREBOUND BOX MANUFACTURERS ASSOC.
Room 1152—327 South LaSalle Street, Chicago 4, Illinois

Users names on request

Zenith

HAS A WIDE RANGE OF CARBURETOR TYPES



TO FIT A WIDE RANGE OF APPLICATIONS!

Are you looking for an unusual size or type of carburetor? Perhaps Zenith* has the answer to your problem. For more than 35 years Zenith has been designing and building carburetors for every type of engine—ranging from single cylinder lightweights to the most rugged and powerful of gasoline engines. The chances are you can use a unit Zenith is now making and avoid the cost of a specially designed carburetor.

On the other hand, if your carburetor requirements are highly specialized, Zenith's engineering experience will prove invaluable in solving questions of placement, efficiency and economy of operation. Just remember, whatever your carburetor problem, it will pay you to look to Zenith for the answer.

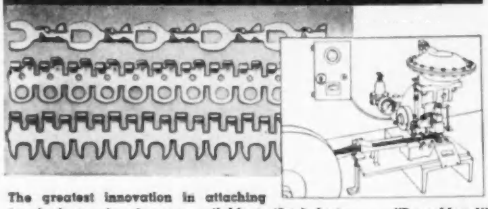
*REG. U. S. PAT. OFF.

ZENITH CARBURETOR DIVISION OF Bendix AVIATION CORPORATION
696 Hart Avenue
Detroit 14, Michigan

MANUFACTURERS OF FINE CARBURETORS AND FUEL FILTERS

Export Sales: Bendix International Division, 72 Fifth Avenue, N. Y. 11, N. Y.

Now Terminals Can Be ATTACHED & SOLDERED *in ONE Automatic Operation!*



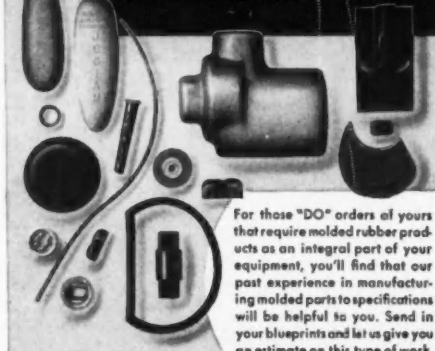
The greatest innovation in attaching terminals to wires is now available to the industry . . . "Pre-soldered" TANDEM TERMINALS! Made in various sizes and types, these remarkable, production-proved terminals (supplied on reels) can be applied at rates up to 1200 per hour by a new Terminal Attaching Machine that cuts off, clinches and solders terminals in one instantaneous operation. Handling of loose terminals, solder and flux are eliminated to reduce costs and boost production on long runs. Standard types available. Send for detailed information, enclose sample of wire and terminal now used. Address Dept. E.

For ordinary runs in moderate quantity we continue to produce
SEPARATE TERMINALS for ELECTRIC WIRES

We also make SMALL METAL STAMPINGS Exact to Customer's Prints. Modern Plant and Equipment. Moderate Die Charges. Precision Work. Prompt Service.

PATTON-MacGUYER COMPANY
Edgewood Station Providence 5, R.I.

PRECISION
MOLDED RUBBER PRODUCTS
sponge • synthetic solid rubber
Manufactured to your Specifications



For those "DO" orders of yours that require molded rubber products as an integral part of your equipment, you'll find that our past experience in manufacturing molded parts to specifications will be helpful to you. Send in your blueprints and let us give you an estimate on this type of work.

DUTCH BRAND

VAN CLEEF BROS. INC.
Manufacturers Rubber Products Est. 1910
CHICAGO 19, U. S. A.

How CLARE Engineers improved the performance of a relay without increasing its size

SPECIFICATIONS

Size: Length: 1 3/64"; Height: 1 1/32"; Width: 1". Dimensions vary with type of coil terminal used. Height shown is maximum (with 8 springs in pileup). **Weight:** Approx. 2 oz. **Coils:** Single or double wound. **Operating Voltage:** to 175 volts d-c. **Armature:** Single- or double-arm. **Contact Arrangement:** Forms A to C available. Maximum 8 springs in pileup. **Mounting:** Two #4-40 screws. Can also be furnished with 2 or 4 mounting studs tapped for #4-40 screws.

● The Clare Type "K" Relay, first of the famous Clare line of small, lightweight, telephone-type relays, is still the mainstay of design engineers who must have superior relays to operate in extremely small space.

Its fast operation, adequate contact pressure, high resistance to shock and vibration, long life and complete all-around dependability have met many complex requirements. Once in a while, however, Clare engineers have been confronted with customers' specifications which this Clare Type "K" Relay would not quite meet.

More often than not this was due to the small spool which limited coil winding to a maximum of 6500 ohms. Clare engineers have met this situation with the new Type "KX" whose sensitivity and operating range are increased by use of a slightly longer coil which can be safely wound to a maximum resistance of 8000 ohms. This additional winding space is gained by a slight change in the design and suspension of the armature which enables the length of the coil to be increased without adding materially to the over-all length of the relay.

The Type "KX", like the Type "K" and Type "R" relays, has the reed armature suspension of special alloy which engineers recognize as one of the subtler reasons for the superior performance of these small Clare relays. The Type "KX" is interchangeable with the Type "K" for mounting.

This new relay is available as either an open or hermetically sealed relay. Call your nearest Clare sales engineer . . . located in principal cities to serve you . . . or write C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials, Ltd., Toronto 13. Cable Address: CLARELAY.

Write for Clare Bulletin No. 116

CLARE RELAYS

First in the Industrial Field

Power and **stamina** for all tough rotary-drive needs

Wherever you want high torque efficiency in a rotary drive that has to withstand a lot of quick starts, sudden stops, instant reversals or continuous use for braking action, you'll want the advantage of a HydrOILic Fluid Motor. These husky, axial-piston fluid drives offer greater durability and trouble-free operation.

HydrOILic Fluid Motors feature advanced engineering that attains highest efficiency *with fewer parts.* This permits more compact construction, saves space, increases strength, permits lower costs, and cuts maintenance needs to the bone. All moving parts of these motors are automatically lubricated in a continuous bath of the oil through which the power is transmitted.

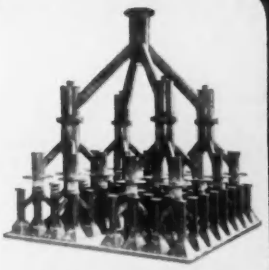
In more than a quarter-century of specialization in the field of oil-hydraulic equipment, Denison engineers have developed many other improvements featured in these fluid drives. The motors have shown their ability to "take it", under all sorts of operating conditions, in all types of plants. And users find that *comparison quickly proves* the advantages of HydrOILic Fluid Motors. Write for complete information on motors to fit your specific needs . . . or send for bulletins on the complete line of Denison HydrOILic Pumps, Control Valves, Pumping Units, Fluid Motors and related equipment.

3 hp to 160 hp sizes • Torque ratings up to 5585 inch-pounds • For operating pressures to 5000 psi • Operating speeds up to 3000 rpm • Can be stopped, reversed, or used for braking at full pressure and speed • Stand up under continuous sudden starts and stops with shock-proof dependability • Operate with full efficiency in any position • Highly compact design saves space, simplifies application, assures extra ruggedness and dependability • Gear reduction attachments and speed controls available for smaller models • Face, flange or foot mountings.

The DENISON Engineering Co.
1157 Dublin Rd. Columbus 16, Ohio

DENISON HydrOILics

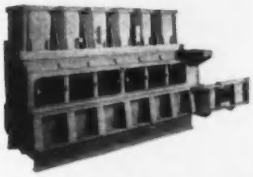
Steel-Weld FABRICATION



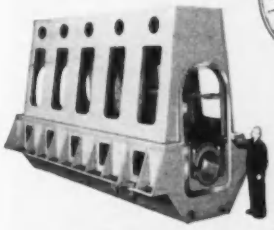
One of Several Parts of a Catalytic Cracking Plant Produced for the Petroleum Industry.

Pressure Vessels for the Chemical and Allied Industries.

Heavy Press and Machine Frames and Bases for the Machine Tool Industry.



Diesel Engine Crank Cases and Frames for the Marine and Electro-Motive Field.



Crank Cases, Frames, and other Parts for Manufacturers of Marine Steam Engines of Uniflow or Multiple Expansion Type.

Use WELDED STEEL for Greater Strength with Less Weight!

This massive clutch and drive housing for a twenty-one ton tractor is another example in which Steel-Weld Fabrication has been employed to good advantage . . . it is typical of heavy machinery parts and assemblies produced and machined by Mahon for many manufacturers throughout the country. If savings in either time or cost can be effected in your product through Steel-Weld Fabrication of parts, or, if you are cramped for manufacturing space, it will pay you to investigate Mahon facilities. You will find in the Mahon organization an unique source with complete, modern fabricating, machining and handling facilities for any type of work regardless of size or weight . . . a source where skillful designing and advanced fabricating technique are supplemented by craftsmanship which assures you a smoother, finer appearing job embodying every advantage of Steel-Weld Fabrication.

THE R. C. MAHON COMPANY
DETROIT 34, MICHIGAN

Engineers and Fabricators of Steel in Any Form for Any Purpose

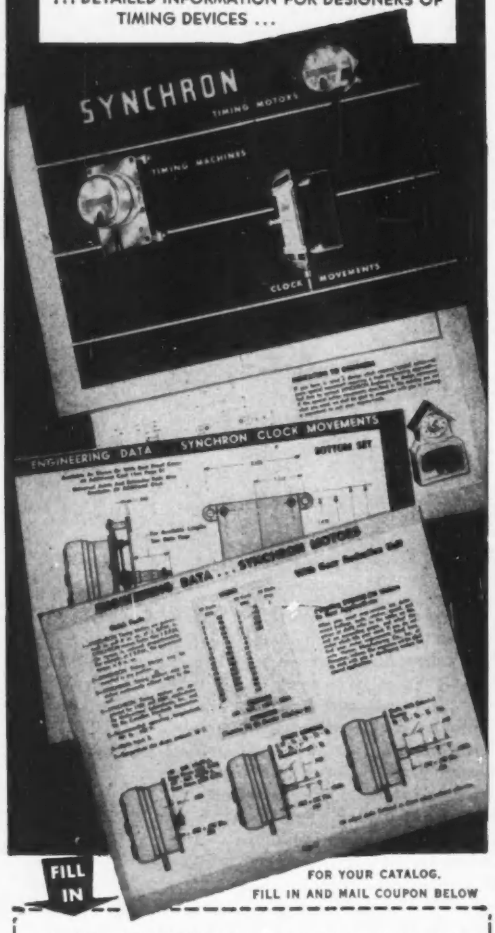
MAHON

READY NOW! CATALOG NO. 50

SYNCHRON

TIMING MOTORS TIMING MACHINES CLOCK MOVEMENTS

... DETAILED INFORMATION FOR DESIGNERS OF TIMING DEVICES ...



FILL IN

FOR YOUR CATALOG.
FILL IN AND MAIL COUPON BELOW

HANSEN MANUFACTURING CO., INC. (7-51)
Princeton 5, Indiana

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Name .....

Position .....

Firm .....

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ONE WASHER INSTEAD OF TWO WITH WEATHERSEAL!

The Weatherseal Washer combines a metal and a compressive, sealing washer, hydraulically bonded and "cured" together to provide just one piece to handle. The compressive material is composition rubber or neoprene, and it does a real job of sealing as this actual cutaway photo shows:

Pat. applied for

Note that the neoprene is extruded under compression to completely seal the outer edge of the metal washer as well as the fastener shank, through the metal sheets to the nut.

APPLICATIONS: Sheet metal roofing and siding • Auto body and chassis assembly • Sheet metal ductwork • Porcelain-to-metal assemblies.

TOPSEALS are fasteners you specify or supply—nail, bolt, sheet metal screw, etc.—assembled in our factory with Weatherseal Washers, ready for use. Reduce your inventory items with TOPSEAL! Write for sample and prices, stating your fastening or sealing problem. Proven production performance and large stocks maintained for quick shipment assures you of meeting your own production schedules.

FABRICATED PRODUCTS COMPANY

WEST NEWTON, PA.

Imperial

TRACING CLOTH FOR HARD PENCILS

• Imperial Pencil Tracing Cloth has the same superbly uniform cloth foundation and transparency as the world famous Imperial Tracing Cloth. But it is distinguished by its special dull drawing surface, on which hard pencils can be used, giving clean, sharp, opaque, non-smudging lines.

Erasures are made easily, without damage. It gives sharp, contrasting prints of the finest lines. It resists the effects of time and wear, and does not become brittle or opaque.

Imperial Pencil Tracing Cloth is right for ink drawings as well.

Imperial

PENCIL TRACING CLOTH

SOLD BY LEADING STATIONERY AND DRAWING MATERIAL DEALERS EVERYWHERE

WATTAGES? HEAT PATTERN? VOLTAGES? SWITCHES? HEAT LOSSES?

Need fast answers on *Electric Heat?*

SHEATH METAL? CONTROLS? THERMOSTATS? TEMPERATURE? RELAYS? ALLOWABLE HEAT UP TIME? MINIMUM FORMING RADIUS? TERMINALS? VOLTAGES?

FOR WAFFLE BAKERS?

FOR WING GUNS?

Relax—you can get them simply by taking advantage of the experience of our engineers. Chances are good that the answer you need is already in our files. If it isn't, we'll get it for you—in a hurry!

We have a wealth of information on heating problems—information it might take you weeks or months or even years to develop on your own. That's because we're specialists at engineering and controlling electric heat. Our men work at it every day . . . for many different manufacturers . . . of many different products.

As a result, we're uniquely qualified to help you—on both civilian production and defense contracts. You'll find TK* Heating Units in everything from waffle bakers to butter warmers, roasters to defrosting apparatus, teakettles to flatirons.

And, as we proved in World War II, we're equally at home with heating elements for guns, gun directors, instrument panels, boat galleys and a host of other aircraft, marine and submarine applications.

So, when you need fast answers, turn your electric heating questions and problems over to us. Rest assured they'll be in good hands!

TK *Heating Units*

*T. M. REG. U. S. PAT. OFF.

TUTTLE & KIFT, INC. 1623 N. MONITOR AVE., CHICAGO 39, ILLINOIS
A SUBSIDIARY OF FERRO ENAMEL CORPORATION

MONOTUBE SURFACE UNITS • OVEN UNITS • TK INFINITE CONTROL • SWITCHES & SELECTORS • WATER HEATER UNITS • FLATIRON UNITS • INDUSTRIAL UNITS

Wagner
ELECTRIC MOTORS
...the choice of leaders in industry

it *pays* to be particular

Wagner

CAPACITOR-START MOTORS

are exceptionally well-adapted to applications with fairly heavy starting loads

The choice of the motor that powers your product is all important. Uniform performance, troublefree long-life operation, a well-known name, and the ability of the manufacturer to provide fast service and repair parts on a nationwide scale, are all factors that add up to satisfied customers for you.

Capacitor-Start Motors
built in ratings from ½ through 3 hp.

Wagner capacitor-start motors are worth looking into for general purpose applications requiring high starting torque. They are available in open or totally-enclosed types, sleeve or ball bearing, with rigid or resilient bases or a machined end plate for flange mounting. Bulletin MU-185 gives full details—write for your copy.

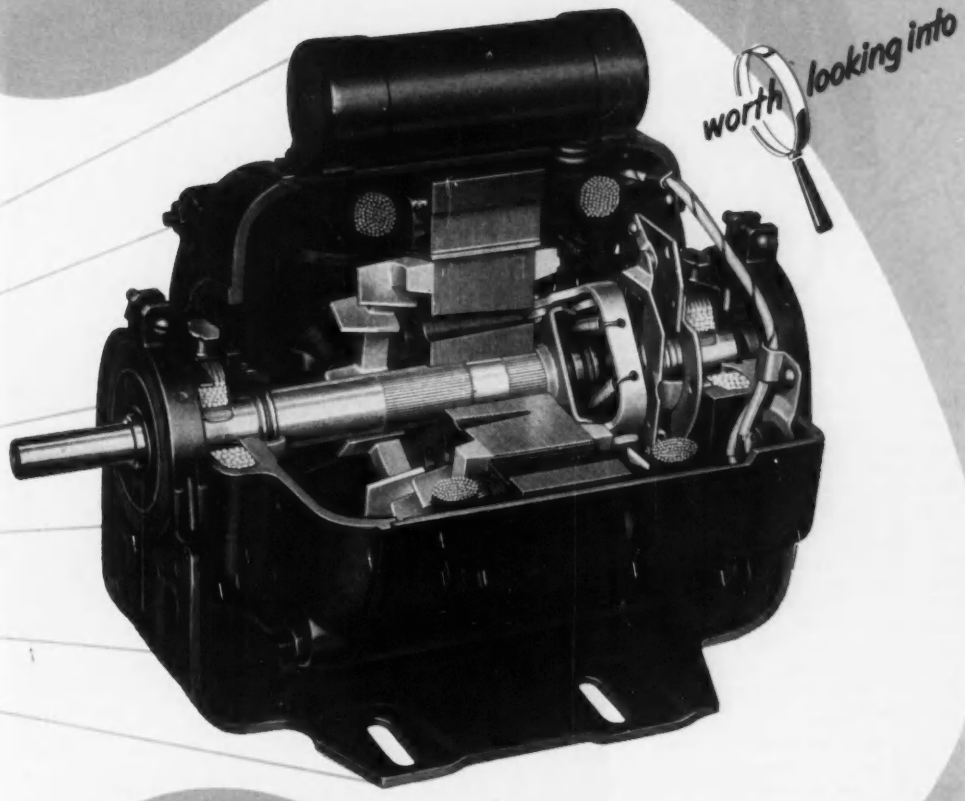
WAGNER ELECTRIC CORPORATION
6406 PLYMOUTH AVE. • ST. LOUIS 14, MO., U. S. A.

Wagner Electric Corporation 1891 1951

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES
AUTOMOTIVE BRAKE SYSTEMS — AIR AND HYDRAULIC

BRANCHES IN 31 PRINCIPAL CITIES

about your choice of motors . . .



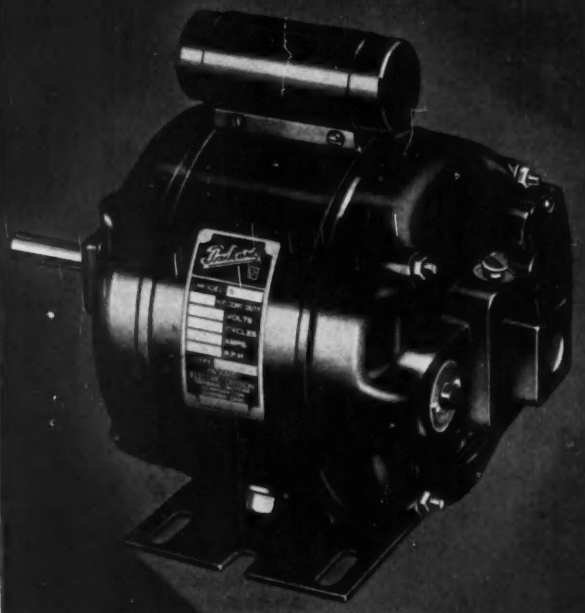
when you choose Wagner Motors

you save time, money, worry, because:

1. Improved engineering features assure long life and efficient operation.
2. Wagner Motors are available in a wide range of types and sizes for every application.
3. Wagner Motors are backed by a liberal warranty.
4. They are available from Wagner Branches in all principal cities.
5. More than 650 Wagner Authorized Service Stations and Parts Distributors *plus* 25 Wagner-owned Service Branches provide on-the-spot service, replacement motors, or genuine repair parts.

Proved Performers

FRACTIONAL HORSEPOWER MOTORS



Increased value for your product and customer good will are plus values that follow naturally when you specify Packard fractional horsepower motors. *Packard's outstanding performance record is known and respected everywhere.*

Thirty-five years' experience, concentrating on the manufacture of fractional horsepower motors alone, has built an exceptional reputation for Packard. And today—with newly expanded facilities for both engineering and manufacturing—Packard continues to concentrate on this one important field.

All the skill and know-how that Packard has accumulated, all the facilities at our command, and all the prestige Packard Electric Motors can lend to your product are yours when you specify Packard. *Packard fractional horsepower motors are proved performers, approved in advance by your customers.*

ELECTRIC MOTORS for

Ironers • Driers • Dishwashers • Pumps • Compressors • Power-Tools • Sprayers • Furnace Blowers • Oil Burners • Milk Separators • Milking Machines • other applications.

Packard

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GM GENERAL MOTORS

Packard Electric Division, General Motors Corporation
Warren, Ohio

DEPENDABLE APPLIANCE MOTORS FOR THIRTY-FIVE YEARS

Fasten it with STAINLESS STEEL

for Better Looks – Longer Life

LEADING PRODUCERS OF FASTENERS USE ALLEGHENY METAL

A complete line of stainless steel fasteners—all types and sizes of bolts and nuts, rivets, wood and machine screws, cotter pins, washers, etc.—are made of Allegheny Metal by the leading manufacturers in this field. Get in touch with them for catalogs and prices, or write us direct.

ADDRESS DEPT. PE-19

Allegheny Metal fasteners are non-rusting, non-staining. They will last as long as, or longer than, the materials they join. You can count on them to stand up through the years—both in strength and in bright good looks.

Best of all, stainless steel fasteners can be used anywhere. It isn't necessary that the materials to be joined are stainless—these corrosion-proof fasteners are the perfect answer for joining other metals, woods, or plastics.

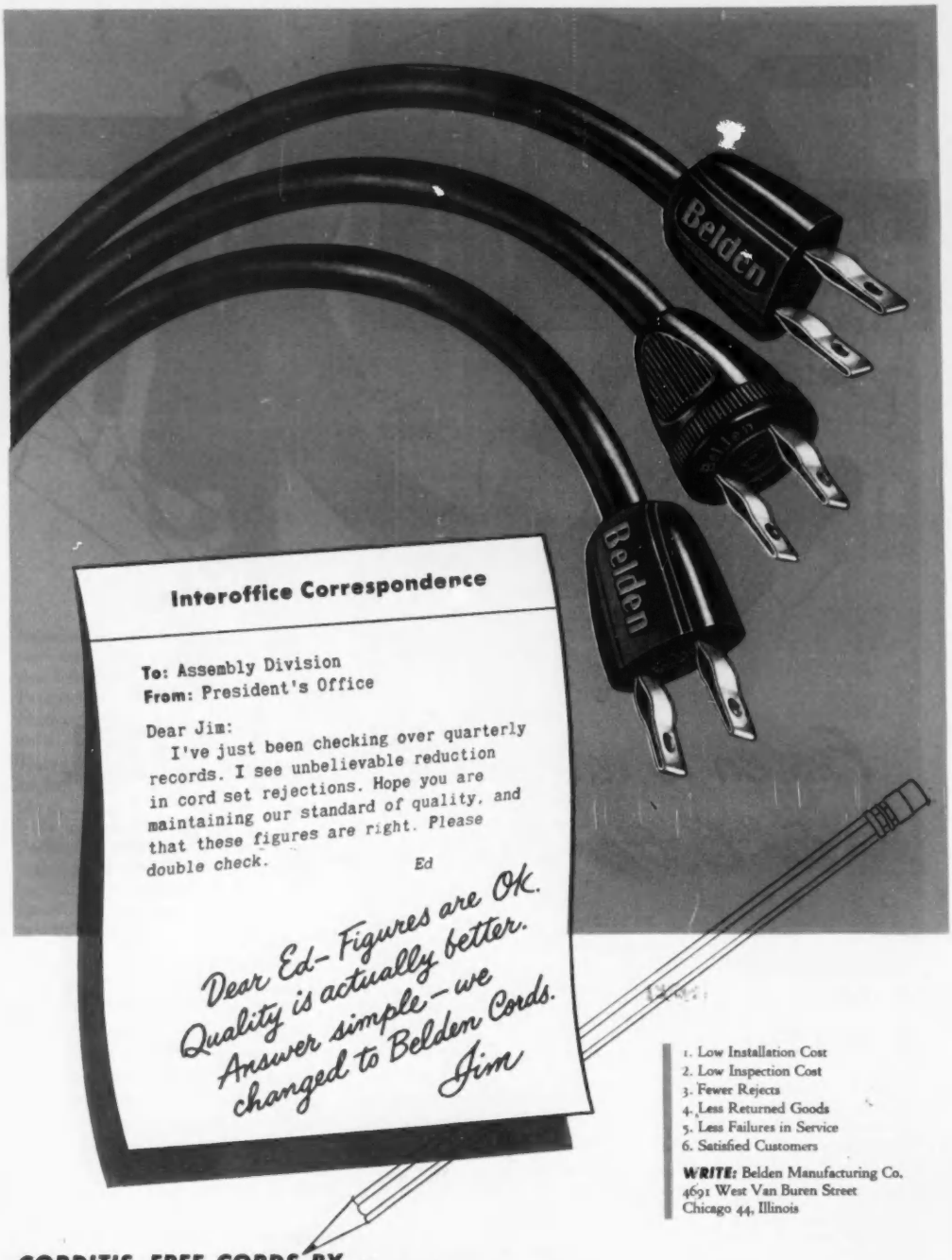
Fasteners made of Allegheny Metal are produced in complete variety—every type and size that your job requires.

For improving quality and reliability wherever they're used—and for the economy of lifetime service—specify fasteners made of the time-tested stainless steel, *Allegheny Metal.* ● For any technical data or engineering help in the use of stainless steel, address *Allegheny Ludlum Steel Corporation, Henry W. Oliver Bldg., Pittsburgh 22, Pa.*

You can make it **BETTER** with

Allegheny Metal

AL
TIME-TESTED STAINLESS STEEL


Belden
Belden
Interoffice Correspondence
To: Assembly Division
From: President's Office
Dear Jim:
I've just been checking over quarterly records. I see unbelievable reduction in cord set rejections. Hope you are maintaining our standard of quality, and that these figures are right. Please double check.
Ed
Dear Ed- Figures are OK. Quality is actually better. Answer simple - we changed to Belden Cords.
Jim

1. Low Installation Cost
2. Low Inspection Cost
3. Fewer Rejects
4. Less Returned Goods
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6. Satisfied Customers

WRITE: Belden Manufacturing Co.
4691 West Van Buren Street
Chicago 44, Illinois

CORDITIS-FREE CORDS BY...

Belden

WIREMAKER FOR INDUSTRY

Just the right balance between *Precision* and *Economy!*

ROLLWAY Tru-Rol ROLLER BEARINGS

Rollway's Tru-Rol cylindrical roller bearings fill a well-defined need . . . afford the design engineer much wider latitude in his choice of means to balance performance and reasonable cost . . . help to ease the pinch on critical materials.

A steel-cage bearing in the steel-cage cost range, TRU-ROL boasts a trueness and precision of roll approaching that of bronze-separator types. That's because of the exclusive Rollway guide-lip . . . an ingenious, low-cost feature that prevents roller-skewing with all its train of evils, such as sliding friction, end-rub, power losses and excessive wear. Investigate TRU-ROL's outstanding record before you specify bearings in medium price range.

Engineering Service

Forty years of specialized bearing experience are at your service in the solving of particular bearing problems. Just ask for a Rollway engineer to consult with you. No cost. No obligation.

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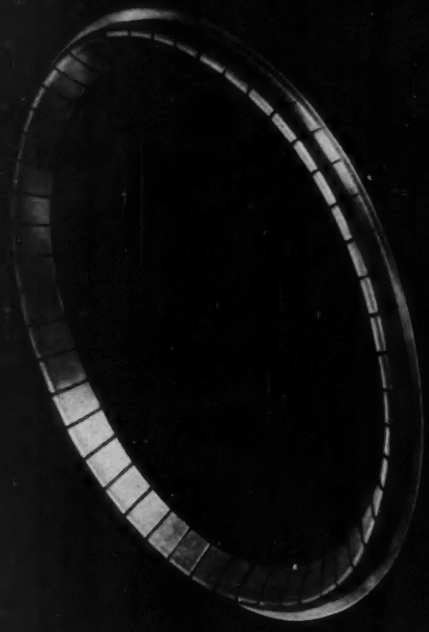
ROLLWAY BEARING CO., Inc.
Syracuse 4, N. Y.

This spring puts the finger on oil leaks



IT'S MADE OF BERYLCO BERYLLIUM COPPER

An ideal bearing oil seal does more than retain the lubricant. It seals against—and is resistant to—mud, dirt, oil, grease and other foreign matter. It resists the corrosive action of water. Such is this seal, made by The Garlock Packing Company.

The beryllium copper spring, formed from Berylco 25 strip, is a vital part of the Garlock oil seal. Each finger independently transmits uniform pressure against the synthetic rubber sealing member. This action provides a low-friction bearing seal on high- or low-speed shafts, even when considerable lateral shaft movement is encountered.

Berylco was chosen for this application because of its ideal spring properties—its resistance to corrosion, fatigue and moderate temperature changes, its formability. Berylco 25 can be formed without regard to grain direction, and subsequent heat-treating produces maximum spring properties.

Take advantage of the technical knowledge of the world's largest producer of beryllium copper. Blueprint your problem or send for sample material.

BERYLCO IS AVAILABLE as casting alloy in ingot form, rounds, rectangles, hexagons or squares, wire and strip.

VALUABLE ENGINEERING INFORMATION on Berylco beryllium copper is compiled in a series of monthly technical bulletins. To receive your copy regularly, write on your business letterhead.

BERYLCO THE BERYLLIUM CORPORATION

DEPT. 1G, READING 2, PENNSYLVANIA

New York · Springfield, Mass. · Cleveland · Dayton · Detroit · Chicago · Minneapolis · St. Louis · Seattle · San Francisco · Los Angeles

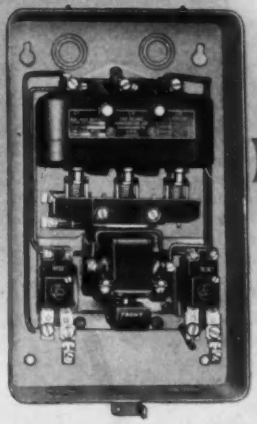
Representatives in principal world-trade centers

Setting new standards in starter performance

The CLARK TYPE "CY" AC MAGNETIC MOTOR STARTERS

with the NEW ARC QUENCHING PRINCIPLE

- No tools needed to inspect contacts. Contacts, coils, and stationary magnet frame easily removed.
- Melting alloy-type overload relays.
- Vertical lift clapper type magnet adapted to straight line guided movement, uses no springs.



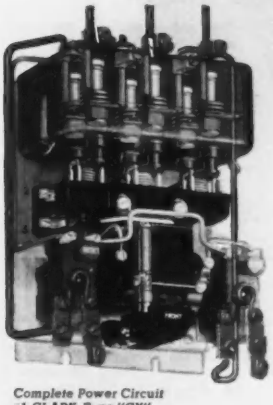
These rugged magnetic starters provide the extra protection and dependable operation of "Mill-Type" heavy-duty construction and design.

another CLARK first!

The CLARK Type "CY" Starters feature the combined use of strong multi-turn magnetic blowouts with twin-break contacts.

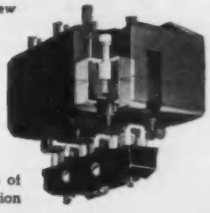
The Type "CY" starters employ an entirely new principle of arc interruption. The blow-out coils are concentric with the contacts. The magnetic field quenches the arc either by lengthening or confining it. By forced rotation the arc moves continually from a hot to a cold spot—minimizing burning or pitting of contacts. The solid upper arc shield prevents the accumulation of hot gases between wiring terminals—minimizing phase-to-phase failures*.

All parts in the arc chamber are copper, brass and steel, thus preventing carbonization. Absence of carbon and soot means longer contact life and lower operating temperatures.



Complete Power Circuit of CLARK Type "CY" Starter, Size 2

Phantom View Showing Arc Shield



*Magnetic blow-out coils are used on all size 2 and 3 Type "CY" starters. Mill-Type construction is used on sizes 0 and 1.

Let a CLARK application engineer show you what this new line of CLARK Type "CY" starters means to you in increased production and lower maintenance.

ENGINEERED ELECTRICAL CONTROL

THE CLARK CONTROLLER CO.

1142 EAST 152ND STREET, CLEVELAND 10, OHIO

The rugged 1½" mesh is being used for heavy duty jobs. The dainty, almost jewel-like 3/16" mesh is used for radio and TV grilles. For sizes between there are hundreds of proven uses, with new ones developing every day.

Expanded Metal is used extensively today, and promises to be increasingly in demand in the future. Architects, engineers and designers are finding new applications constantly. Everywhere that strength without bulk is desired, where substantial saving in weight is important, where the passage of light and air is wanted, where decorative effects are sought, there is a place for PENMETAL Expanded Metal.

Standard or flattened, light or heavy gauge; large or small mesh; carbon or stainless steel, copper, aluminum or other metals; unfinished, polished, painted or enamelled; either exposed or concealed; it has endless possibilities for efficient, economical use.

May we send samples and descriptive literature to you?

82nd PENMETAL YEAR

Penmetal

PENN METAL COMPANY, INC.

General Sales Offices: 299 East 42nd Street, New York 17, N. Y.

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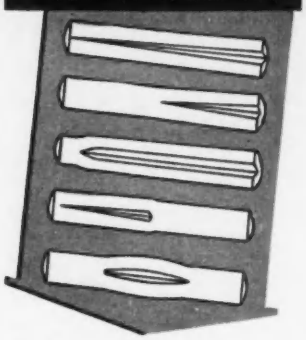
Seattle Los Angeles San Francisco Dallas Parkersburg, W. Va.

Is there a spot in your specs for Groov-Pins?



Study the specifications for your product more closely. Are there places where Groov-Pins could reduce assembly time —improve compactness, strength, durability?

The manufacture of superior quality grooved press fit fasteners is an old story to us. We have been doing it for twenty-five years and have solved the pin fastening problems of many prominent manufacturers. We believe we can help you, too.

We are confident that today, as always, Groov-Pins are the best pin fasteners you can use because:

(1) They reduce assembly time and costs. Installation requires only straight drilled holes—no tapping, reaming, milling, peening.
(2) They are amazingly resistant to vibration and shock—make neat, rigid, strong assemblies.
(3) They are available in seven different standard types and in special designs to suit requirements.
(4) They are equal or superior in shear strength to any similar fastener of the same diameter and material.
(5) They can be driven by hand, air cylinder or hydraulic press.
(6) They can be removed and used repeatedly.
(7) Thousands of applications have demonstrated their advantages for many years.

Send for samples and literature and see for yourself.

Also manufacturers of Tap-Lok Inserts.

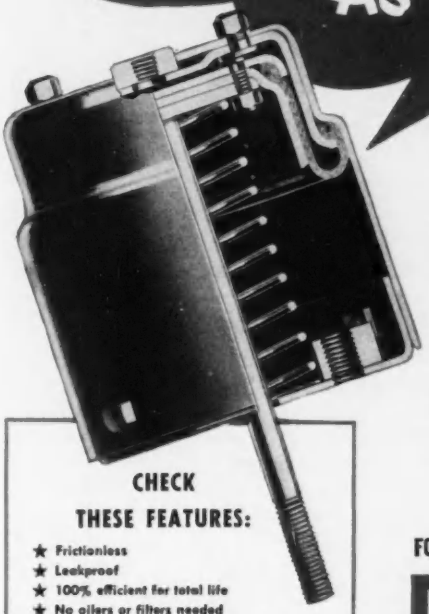
GROOV-PIN

GROOV-PIN CORPORATION

2015 Kerrigan Avenue
Union City, N. J.

ON OLD OR NEW MACHINE TOOL OPERATIONS—

YOU CAN STEP UP YOUR PRODUCTION AS MUCH AS 30%



....WITH THIS SIMPLE, RUGGED, LOW COST AIR CYLINDER!

The pressure for production is on! Manufacturers everywhere find it increasingly difficult to keep pace with the demands of the day. But there is a way—a brand new way requiring no addition to manpower, no addition to plant facilities. The answer? Remarkable Bendix-Westinghouse Robotair Industrial Controls. With their wide range of applications, Robotair controls offer you amazing improvements in production speed and economy through increased productivity of man and machine at *unbelievably low initial cost.* Robotair units are available as original equipment for machinery manufacturers or for easy installation on shop equipment.

Send today for an informative booklet and find out how you can cut costs, speed production with Robotair! Address Bendix-Westinghouse Automotive Air Brake Co., Dept. A, Elyria, Ohio.

CHECK THESE FEATURES:

- ★ Frictionless
- ★ Leakproof
- ★ 100% efficient for total life
- ★ No oilers or filters needed
- ★ Holding pressures up to 5000 lbs.
- ★ Diaphragm has rolling action and exceptionally long life
- ★ Made from high grade steel stamping—all metal parts cadmium plated
- ★ Chrome Molybdenum Steel Push Rod heat-treated for maximum toughness
- ★ Easily installed

FOR HOLDING, CLAMPING, BENDING, SWEDGING, STAKING, RIVETING

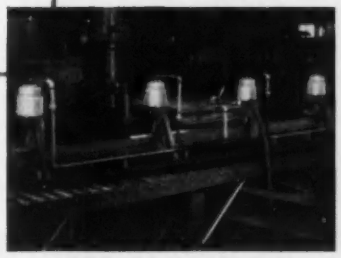
ROBOTAIR

THE INDUSTRIAL AIR CONTROL OF A THOUSAND USES

BENDIX-WESTINGHOUSE ROBOTAIR

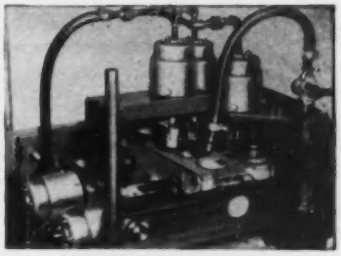
Bendix-Westinghouse

Bendix-Westinghouse Automotive Air Brake Company Elyria, Ohio



REDUCES OPERATOR FATIGUE

Four Rotochambers installed on the fixture in this spot welding operation replaced cumbersome hand clamps, saving time, greatly reducing operator fatigue.



SPEEDS INSPECTION METHODS

Installation of Rotochambers on this water test operation for engine castings eliminated hand operated fixtures, thereby speeding inspection and cutting costs.

R&M MOTORS Help Cut the Costs of Cutting Metals QUICKLY

● Every compliment users bestow upon the Stone "Swing-Cut" Metal Cut-Off Machine is also a tribute to R & M Motor Parts which power this versatile unit. A 16-inch cutting wheel, turning at 2380 r.p.m., cuts bars, rods, tubing, pipe, structurals, etc., at an average speed of only *four seconds* for each square inch of metal. That gives you a good idea of *why* Stone came to R & M.

THERE'S NO SUBSTITUTE FOR EXPERIENCE

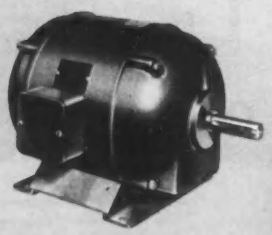
And, like so many other manufacturers, Stone Machinery Co., of Manlius, N. Y., found *R & M engineering* a welcome aid in solving exacting problems. For, in addition to standard motors and motor parts from 1/200 to 125 h.p., Robbins & Myers has long been famous for meeting *specific* requirements. Note the small size of the Stone 5 h.p. motor. It's high-torque, induction, with a rotor speed of 3500 r.p.m., and a geared-in-head reduction.

THESE MOTORS ARE SALESMEN, TOO

On permanent tools or portable types where the powering must be right, you'll find R & M Motors have what it takes for the *utmost* in performance. They make *good friends* for the equipment they drive—and they also make friends for us.

YOU GET EXTRA PROTECTION FROM DAMAGE BY MOISTURE IN NEW R & M "ALL-WEATHER" MOTORS

Standard R & M Integral Motors are now completely "Weatherized"—at no extra cost to you. Inside and out, they're fully protected from harmful rust and corrosion. Get the money-saving facts today on these exclusive, long-service benefits. Write for Bulletin P-400-E.

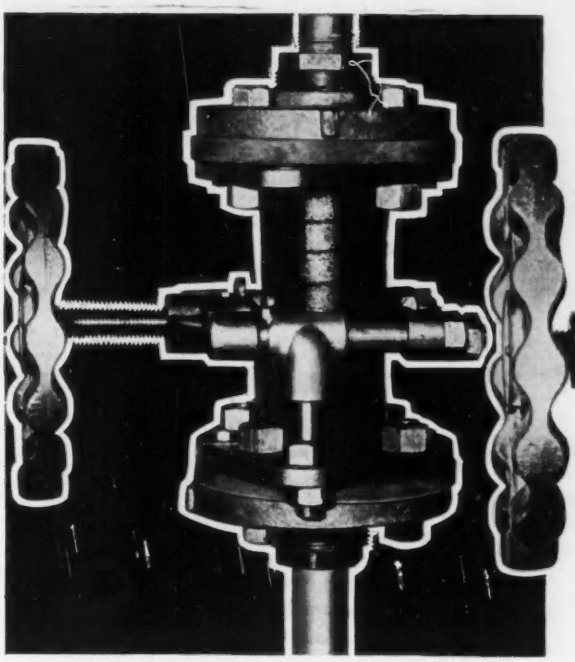


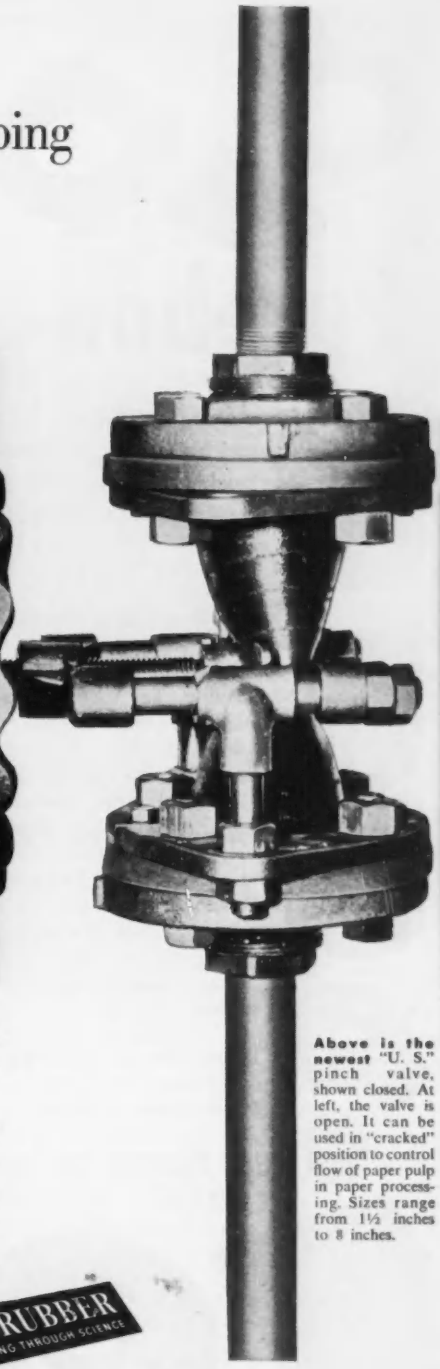
ROBBINS & MYERS • INC.

SPRINGFIELD 99, OHIO • BRANTFORD, ONTARIO

MOTORS • HOISTS • CRANES • FANS • MOYNO PUMPS

What's U. S. Rubber doing with pinch valves?





United States Rubber is squeezing out new production economies with its latest pinch valve. Designed for pipe lines carrying abrasive or corrosive mixtures, the valve eliminates "water hammer", breaks up galvanic action in pipe lines.

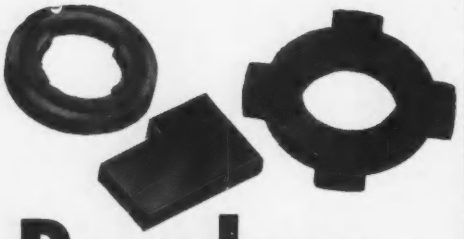
The valve reduces replacement costs because it can be refitted to new valve bodies. No packing or repacking is needed. Its design is very compact, with mechanism, retaining rings and pinch valve body in a single unit—an advantage where space is limited. The valve is available in neoprene for oil-resistance, or butyl rubber for high heat and severe acid conditions, or pure gum stock for food and beverage conveyance. Write to address below.

Above is the newest "U. S." pinch valve, shown closed. At left, the valve is open. It can be used in "cracked" position to control flow of paper pulp in paper processing. Sizes range from 1½ inches to 8 inches.

PRODUCT OF U.S.RUBBER SERVING THROUGH SCIENCE

UNITED STATES RUBBER COMPANY

MECHANICAL GOODS DIVISION • ROCKEFELLER CENTER, NEW YORK 20, N. Y.



Purebon

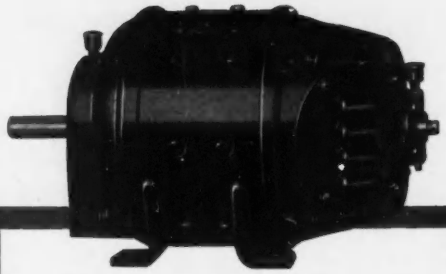
solves many problems

caused by sliding or rotating parts which are difficult or impossible to lubricate

A constantly increasing stream of problems are facing engineers and designers today involving sliding or rotating parts where lubrication is difficult or impossible. For such applications, Purebon, the mechanical carbon, is often the ideal answer. Typical applications are seal rings, bearings, pistons, piston rings, pump vanes, valve seats, meter discs, and a host of similar items. Purebon comes in a wide variety of grades. It is strong, tough, readily machineable and in many cases can be molded directly to size.

Bulletin No. 482 tells the complete story of Purebon. Write for your copy today.

PURE CARBON CO., INC.
443 HALL AVE. ST. MARYS, PA



ALL PEERLESS MOTORS ARE "Peerless Registered"

MORE than 90% of all Peerless Motors are custom manufactured to meet the specific operating requirements of the equipment with which they are to be used.

So we "Peerless Register" every motor before shipment. The words "Peerless Registered" are a trademark, recorded in the U. S. Patent office. Only Peerless Motors can bear this phrase, and only Peerless Motors offer you this protection.

This registration record is assurance to both you and your customer that the Peerless Motor has been properly designed for your equipment so as to give best possible performance and long, satisfactory service. And the registration record makes possible the quick identification of any Peerless Motor — anywhere.

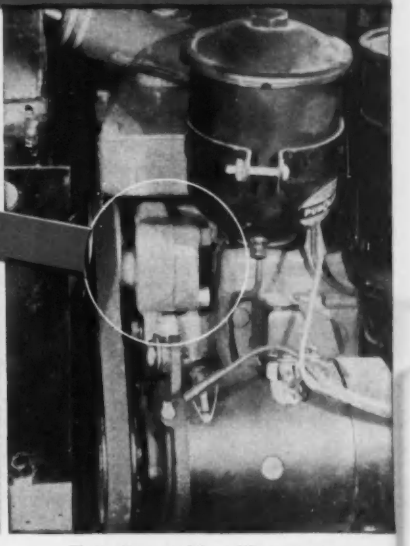
THE PEERLESS ELECTRIC CO., WARREN, OHIO
Manufacturers of Quality Motors Since 1893
Single Phase • Polyphase • Direct Current • ¼ to 15 H.P.

ALL *Peerless Motors* ARE "PEERLESS REGISTERED"

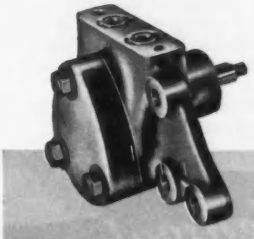
Another Job for Pesco HYDRAULIC MUSCLES

BW

"The sensitive response of the hydraulic system permits such trigger-fine adjustment that operators are loud in their appreciation," says Massey-Harris . . . *the sales power of hydraulic power in action.*



Circle shows position of Pesco pump.



Pesco pump designed for Massey-Harris Pony tractor. Capacity: 2.5 g. p. m. @ 2880 r. p. m. @ 1000 p. s. i.

Pesco *Dual Purpose* Pump Eliminates Extra Power Shaft on Massey-Harris Pony

The problem was to eliminate all unnecessary weight and cost and save space on a small tractor.

So Massey-Harris tractor engineers and Pesco hydraulic engineers teamed up . . . together came up with a specially designed dual purpose hydraulic pump to serve as both pump and fan bearing mounting.

Result: less space and weight required . . . necessity for an extra motor power shaft is eliminated.

Such teamwork between Pesco and client engineers is frequent. Matching hydraulic know-how and skills with the engineering knowledge of a manufacturer's engineering staff is the way we at Pesco like to work. It is teamwork that puts the sales power of hydraulic power to work to full advantage for our customers.

If you have a problem in hydraulics Pesco engineers will gladly co-operate with your engineers to solve it. Write today.

engineering Pesco production

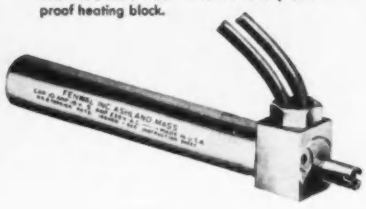
PRODUCTS DIVISION

BORG-WARNER CORPORATION

24700 NORTH MILES ROAD BEDFORD, OHIO

Multi-Purpose Thermostat helps solve heat-control problem in Bede Paint Heater

BEDE PAINT HEATERS, used to speed up paint spraying and save material by heating both paint and air, rely on Fenwal Block Head THERMOSWITCH Unit installed in explosion-proof heating block.



When Bede Products, Inc. originally designed the Bede Paint Heater it faced a primary problem: safety.

Underwriters' Laboratories, Inc. cautioned against the danger of electrical heating in paint spraying areas. So a metal block with pipes for paint and air was made explosion-proof by a special surface cover and fittings. The temperature control unit, which had to be compact, economical and accurate, could then be located in the block, flanked by heating elements.

LOW-COST SOLUTION

A Fenwal THERMOSWITCH Unit — 8/10 of an inch in diameter — met all specifications: low cost, precise performance, compact size, high current-carrying capacity. By this, it enables Bede Paint Heaters to lower the cost of paint spraying throughout industry.

YOUR PROBLEM?

Many types of control problems can be solved by easy-to-install, easy-to-maintain Fenwal THERMOSWITCH thermostats. Their activating control element is the single-metal shell that expands or contracts *instantaneously* with temperature changes, making or breaking the totally enclosed electrical contacts. Through this unique principle, THERMOSWITCH Units effectively control *many* variables where heat is a factor.

Find out now how Fenwal THERMOSWITCH Units can help you in *your* product. Mail coupon today.

Fenwal

THERMOSWITCH®

The Precision, Multi-Purpose, Thermostat Control

SENSITIVE . . . but only to heat

FREE! **Get this bulletin . . . see what Fenwal THERMOSWITCH Units can do for you.**

Just fill in coupon and mail . . . no obligation.

FENWAL, INCORPORATED, 27 Pleasant St., Ashland, Mass.
111 South Burlington Ave., Los Angeles 4, Cal.
TEMPERATURE CONTROL ENGINEERS

Name ..... Position .....

Company .....

Street .....

City ..... Zone ..... State .....

I am chiefly interested in the applications checked:

- ☐ Heating
- ☐ Cooling
- ☐ Humidity Control or Detection
- ☐ Alarm (over-temperature, under-temperature)
- ☐ Vapor Control
- ☐ Timing (thermal)
- ☐ Radiant Heat Control
- ☐ Pressure Control (by controlling vapor temperature)

OTHER (Please fill in your special requirements).....

.....

.....

Color problems

IN POLYSTYRENE

and what to do about them

Limited supplies of important elements have created color problems in translucent and opaque Polystyrenes for manufacturers and molders alike.

Certain pigments have made possible Polystyrenes with colors that have excellent stability to heat and light. These pigments produce a wide range of colors in the red-to-yellow spectrum, as well as some greens and even a few blues. Now, by government orders, supplies of these pigments are limited, except for the most vital defense uses.

There is a further problem, other pigments used as opacifiers in all translucent and opaque Polystyrenes except black, are in exceedingly short supply.

Through customer cooperation and by inventory management of raw material supplies, we have been able to produce Koppers Polystyrene without changes in color formulations. It is possible that in time we will be required to develop new formulations, using replacement colorants, for some colors.

When you use these new color formulations consider the application carefully in terms of necessary heat and light stability. For your protection, when replacement color formulations become necessary, recommendations concerning their use will be supplied.

As always, Koppers will work closely with customers to help them obtain best results. Before planning production, check with us.

KOPPERS

Koppers Plastics

Koppers Polystyrene has made Many Products Better and Many Better Products Possible.

KOPPERS COMPANY, INC., Chemical Division, PITTSBURGH 19, PA.

SALES OFFICES: NEW YORK · BOSTON · PHILADELPHIA · CHICAGO · DETROIT · LOS ANGELES

WIRE MESH

Maybe it all *does* look pretty much the same at first glance. But when a firm has been making wire mesh for 70 years man and boy, there's bound to be a little more to it than meets the eye —a little more know-how in engineering and weaving, a little more quality in the product, a little more service and satisfaction to the user.

JELLIFF WIRE MESH is woven in all ductile metals

JELLIFF WIRE MESH is woven in all commercial weaves

JELLIFF WIRE MESH is woven in widths up to 72 inches

JELLIFF WIRE MESH is economical. Every foot runs true to the specifications.

JELLIFF WIRE MESH

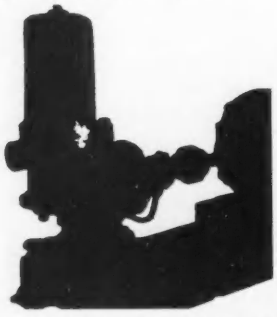
is a quality product and has been for 70 years. You can depend on it.

Write today for full details about JELLIFF WIRE MESH, JELLIFF WIRE - MESH PRODUCTS, and JELLIFF'S CONSULTATION SERVICE on wire-mesh engineering. Address Department 24.

Kraissl
ROTARY AIR PUMPS

For Vacuum and Pressure

Designed for high efficiency—for the packaging and printing machine fields. Rigorous on-job tests prove Kraissl pumps are the economy answer to your vacuum and air-under-pressure problems. Exclusive Kraissl design assures you maximum performance—and lower costs. Compact and lightweight—with exceptionally large capacities for size; force-feed lubrication system gives continuous heavy-duty service.



***FREE!** Bulletin A-1289 gives you complete data on Kraissl Rotary Air Pumps. Write for it today.*

If you have any special problems—if you need any detailed information—please write us fully. You will receive a prompt and detailed reply.

Features of Kraissl Class 25 Air Pumps

- Run at direct motor speeds — but not limited to motor operations
- Integrated oil-air filter available
- Forced-feed lubrication system
- Compact and lightweight
- High capacities

KRAISSL CO Inc.

297 Williams Ave., Hackensack, N. J.

Important SAVINGS to VOLUME users of small parts

..like these

thanks to **MULTI-SWAGE**

If you need small tubular metal parts like these in large VOLUME, Bead Chain's MULTI-SWAGE Process can mean important savings to you.

Much Cheaper Than Solid Pins

Many prominent users of solid pins for electronic and mechanical purposes have cut costs by switching to Multi-Swaged *tubular* pins . . . without sacrificing strength or accuracy.

Typical Applications—

As terminals, contacts, bearing pins, stop pins, male-female connections, etc., in a wide variety of products such as Business Machines, Ventilator Louvres, Toys, Radio and Television Apparatus, Terminal-boards, Electric Shavers, Phonograph Pickups, etc.

Send part (up to ¼" dia. and to 1½" length) and your specs for a quotation or write for DATA BULLETIN.

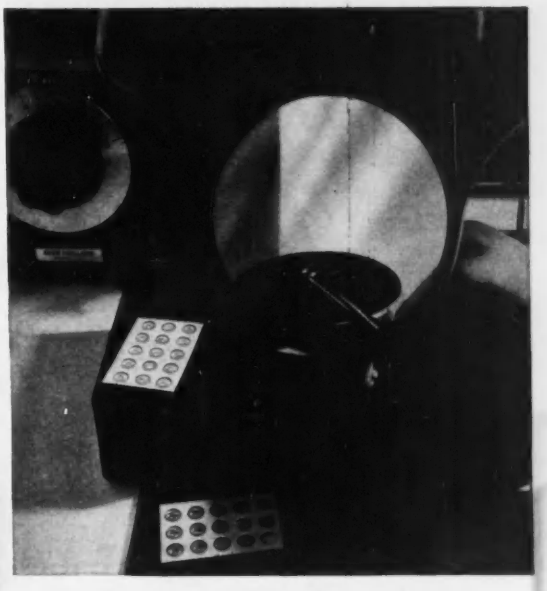
B®

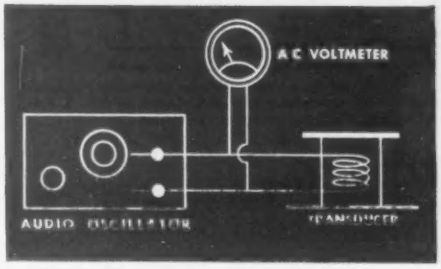
THE BEAD CHAIN® MFG. CO.

92 Mountain Grove St., Bridgeport 5, Conn.

Manufacturers of BEAD CHAIN — the kinkless chain of a thousand uses, for pull and retaining chains and other industrial uses, plumbing, electrical, jewelry, fishing tackle and novelty products.

marion methods
MEASURE HAIRSPRING *TORQUE* WITH SOUND WAVES

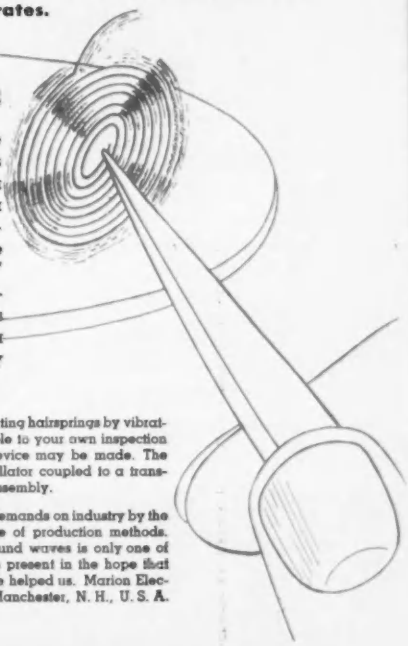




Marion's Hairspring Inspection method permits *100% inspection and control of hairspring characteristics* at high production rates.

Help yourself to marion methods

THE MARION METHOD of hairspring inspection takes advantage of the relationship between the torque of the hairspring and its natural resonant frequency. Initial calibration is made with a standard torsiometer and frequency is adjusted to resonate a hairspring of known torque. Hairsprings of correct torque specifications resonate when held in tweezers placed against the vibrating surface. Amplitude adjustment permits "Go-No-Go" Inspection to ±1% of specified torque. With this method, inspection rates of 500 to 600 springs per hour may be achieved. This technique affords production torque control to close limits on a 100% basis, rather than the normal spot checking provided by standard torsiometers.



NOT FOR SALE — Marion's Method of inspecting hairsprings by vibrating them at audible frequencies may be adaptable to your own inspection problems. The illustrations show how such a device may be made. The one pictured uses a Hewlett-Packard audio oscillator coupled to a transducer which may be a modified F. M. speaker assembly.

OTHER MARION METHODS — Current demands on industry by the mobilization program accentuate the importance of production methods. Hairspring torque measurement by means of sound waves is only one of a number of methods which Marion proposes to present in the hope that some of them can help you as much as they have helped us. Marion Electrical Instrument Company, 415 Canal Street, Manchester, N. H., U. S. A.

MANUFACTURERS OF MARION RUGGEDIZED PANEL INSTRUMENTS

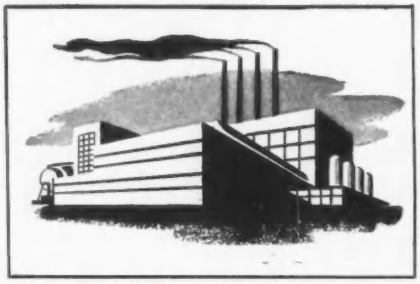
marion meters

Bendix-Skinner

ORIGINATOR OF **MICRONIC** FILTRATION

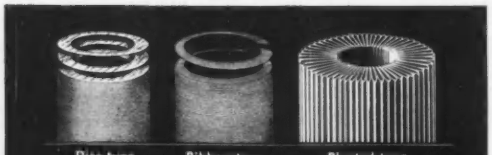
the *Finest*

Way to Make Liquids Come Clean



Nine times out of ten ***Bendix-Skinner*** filters will supply the "finest" answer to your problem. No magic—just the simple fact that ***Bendix-Skinner*** has developed entirely new and exclusive filtering techniques in twenty years of tackling the tough jobs. We'll welcome an opportunity to prove it. An inquiry costs you nothing and may save you much.

Over 350 Models *providing filtration from 1/2 micron (.000019") upwards at flow rates from 1 to 5000 g.p.m.*



Disc-type Ribbon-type Pleated-type

SKINNER PURIFIERS DIVISION OF

1502 TROMBLY AVENUE,
DETROIT 11, MICHIGAN

Bendix AVIATION CORPORATION

Export Sales: Bendix International Division, 72 Fifth Ave., N. Y. 11, N. Y.

Announcing

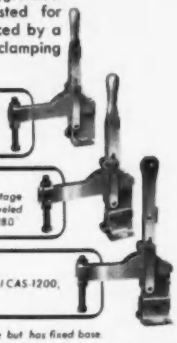
NEW CAM CLAMPS

These cam-action clamps were designed for applications where parts (such as castings, larger forgings, or stacked stampings) having variable thickness, are to be held. They are the only big cam clamps known that provide convenient means for locating the spindle assembly along the toggle bar. The spindle itself is easily adjusted for clamping height, and can be replaced by a special pressure pad to suit other clamping requirements.

MODEL CAV-1200
Recommended force at end of toggle bar 1200 lbs. Recommended force 3⅛" from front of base, 1900 lbs.

MODEL CAS-1200
This clamp has the additional advantage of permitting the toggle bar to be swiveled around the base to any position within 180°

MODEL CAS-2000
This clamp has the same features as Model CAS-1200, but for 2000 lbs. clamping force.



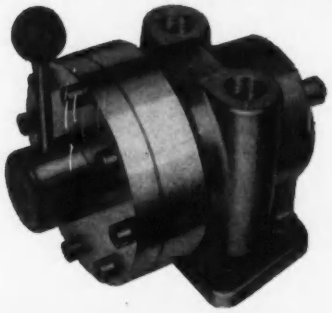
MODEL CAV-2000—*similar to above but has fixed base.*

This entire series is also available without cam action (with fixed locking). Catalogued as Models V-1200, S-1200, V-2000, and S-2000. Complete catalog sent on request.

KNU-VISE PRODUCTS **LAPEER MFG. CO.**

3058 DAVISON ROAD • LAPEER, MICHIGAN

The *Controlled Flow*



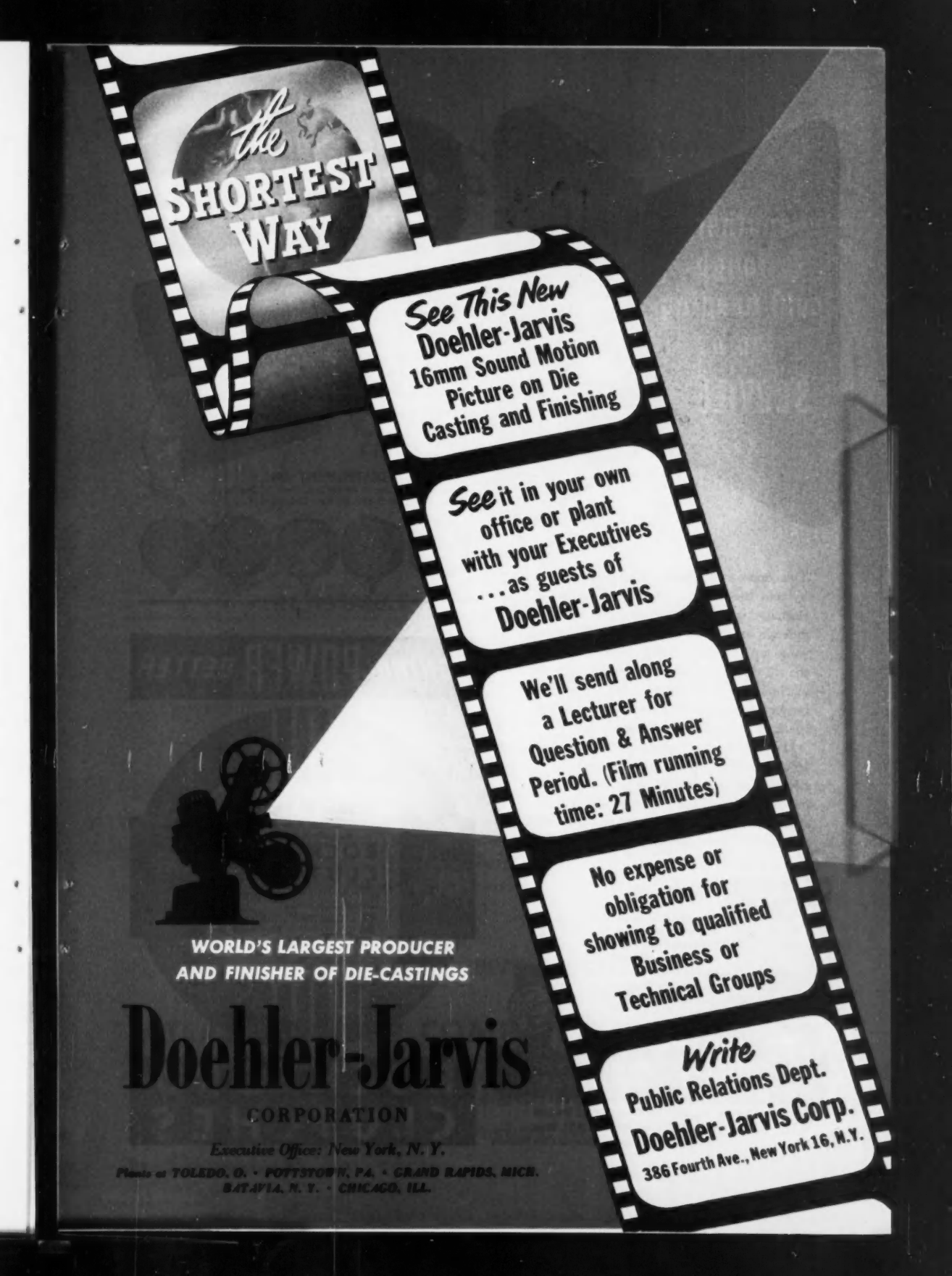
HYDROPUMP

PROVIDES COMPLETE CONTROL OF
VOLUME • • • DIRECTION • • • PRESSURE
AT THE PUMP without Valves

These are only some of the features that the HYDROPUMP offers. For complete information, write for Bulletin 100-P.

MILWAUKEE HYDROPOWER, INC.

3445 N. 35th St. Milwaukee 16, Wis.


the SHORTEST WAY
See This New Doehler-Jarvis 16mm Sound Motion Picture on Die Casting and Finishing
See it in your own office or plant with your Executives ...as guests of Doehler-Jarvis
We'll send along a Lecturer for Question & Answer Period. (Film running time: 27 Minutes)
No expense or obligation for showing to qualified Business or Technical Groups
Write Public Relations Dept. Doehler-Jarvis Corp. 386 Fourth Ave., New York 16, N.Y.
WORLD'S LARGEST PRODUCER AND FINISHER OF DIE-CASTINGS
Doehler-Jarvis
CORPORATION
Executive Office: New York, N. Y.
Plants at TOLEDO, O. • POTTSTOWN, PA. • GRAND RAPIDS, MICH. BATAVIA, N. Y. • CHICAGO, ILL.

another tough cold heading job by SCOVILL

This copper transformer stud is being produced by cold heading at Scovill for a well-known electrical manufacturing company. Note the different diameters and shapes, the staked wings and "captive" fiber washer. Copper, though difficult to work on automatic screw machines, is admirably suited for cold heading. By preserving the flow lines in the metal, cold heading also produces a stronger part.

Although this particular part is designed for an electrical component, it may spark a solution to some similar problem you have, involving different diameters, washer assembly and staked wings. For further information send your sample or blueprint.

"Guide to the Profitable Use of Cold Heading" —Bulletin No. 2 describes the advantages and limitations of this process for the designer. It's free for the asking.

RECESSED HEAD SCREWS • SEMS • TAPPING SCREWS
STANDARD MACHINE SCREWS • SPECIAL COLD HEADED PARTS

SCOVILL FASTENERS AND SPECIAL PARTS

INDUSTRIAL FASTENER SALES, WATERVILLE DIVISION
SCOVILL MANUFACTURING CO., WATERVILLE 14, CONN.
Montclair, N. J. • Detroit • Wheaton, Ill • Los Angeles • Cleveland • San Francisco

Know the scope of the MARSH line of pressure gauges

There are literally thousands of combinations of types, ranges, case styles and connections in the broad Marsh line of pressure, vacuum and compound gauges. As a result, gauge requirements that would be "special" to others are often standard to Marsh.

This means that we can meet your gauge needs better and more economically . . . whatever the service condition, quantity or design requirement. To know the scope of Marsh Instruments just ask for the new fact-filled catalog.

MARSH INSTRUMENT CO.
Sales affiliate of Jas. P. Marsh Corp., Dept. 39, Skokie, Ill.
Export Dept.: 155 E. 44th St., New York 17, N. Y.

CONTROL POWER BETTER

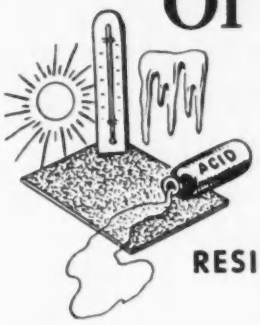
ROCKFORD CLUTCHES

COLOR

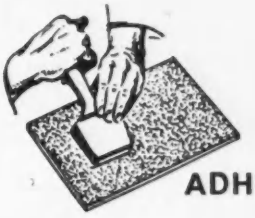
TOUGHNESS

ZAPON Helps Solve Problems Of "Conformance"

VISCOSITY



RESISTANCE



ADHESION

DEFENSE ORDERS bring with them the need for conformance with government specifications. ZAPON can help.

ZAPON *Service From Every Angle* brings you finishes that meet government "specs" in the drum. They must comply with the "specs" to assure highest performance requirements in the field.

ZAPON technicians tackle any problem of "conformance" on your own production line. Let ZAPON help set up your finishing department to fill government orders with speed and economy.

Service from every angle... that's

ATLAS POWDER COMPANY

Industrial Finishes

Stamford, Conn. · North Chicago, Ill.

ZAPON

REG. U. S. PAT. OFF.

quick facts ABOUT A-C ENGINES

...and why it pays to use them in your products

LOW COST

Allis-Chalmers Power Units are mass-produced along with tractor engines by the thousands. This means maximum production economy . . . lowest cost to *you*.

POWER SUITED TO THE JOB

Five sizes make it easy to fill any power requirement. Use them singly, or in combination instead of one larger, costlier engine. Choice of fuels.

REAL LUGGING ABILITY

Designed for tough tractor service, A-C Power Units have high torque characteristics to take overloads in stride, even when throttled way down.

PROMPT SERVICE

There are thousands of A-C dealers throughout the nation, and one of them is near *you*. He stocks genuine A-C parts and is ready to give you service when and where you want it.

Investigate rugged A-C engines for low-cost, dependable power on *your* products. Our engineers will gladly work with you in selecting the unit to meet your requirements.

ALLIS-CHALMERS

TRACTOR DIVISION • MILWAUKEE 1, U. S. A.

Model*	RPM	Max. Bhp.
B-125	1500-1800	24.5-28.0
W-201	1400-1800	33.5-40.5
U-318	1200-1400	45.0-50.9
E-563	1050	74.0
L-844	1050	110.0

*Figures represent cu. in. displacement.

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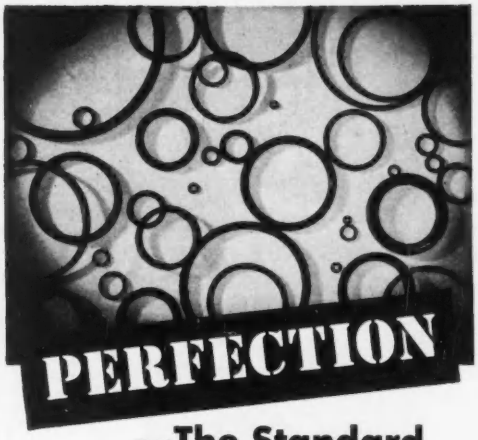

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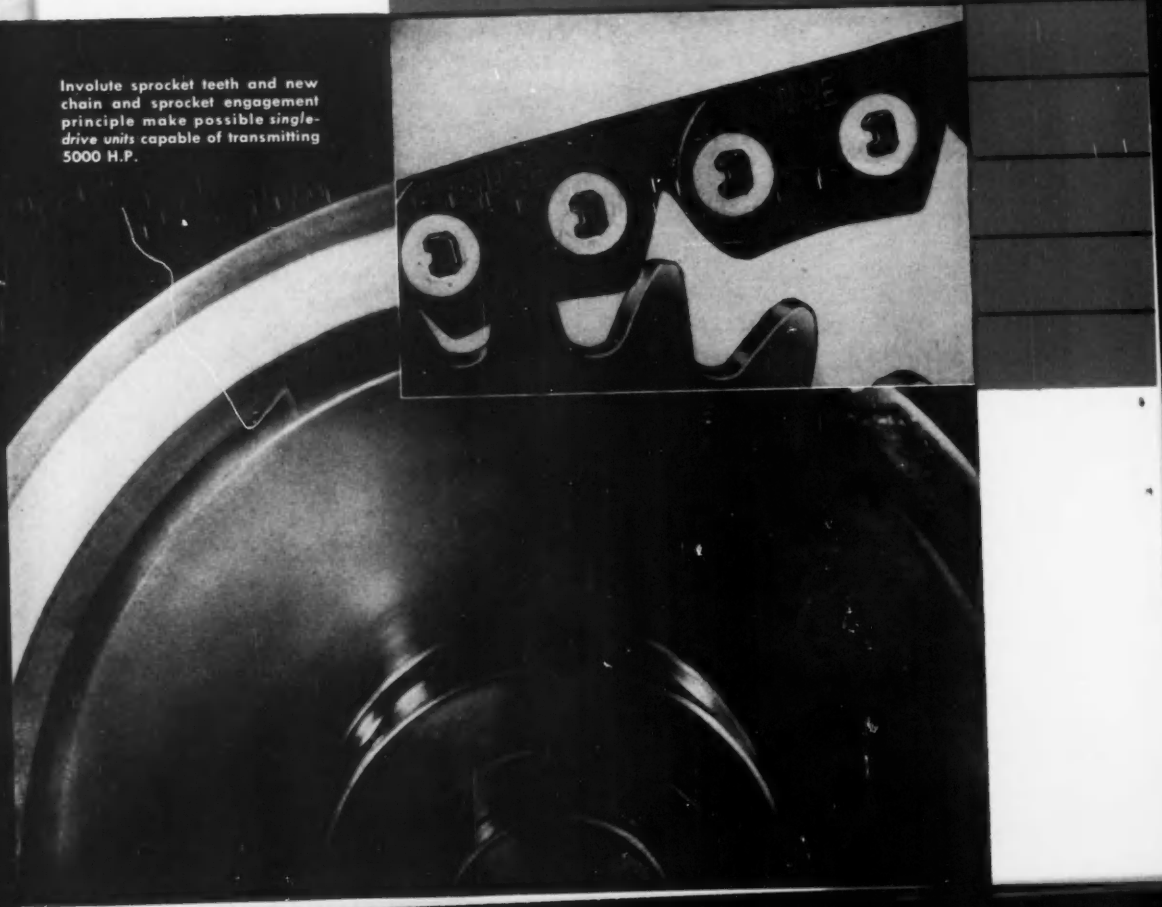

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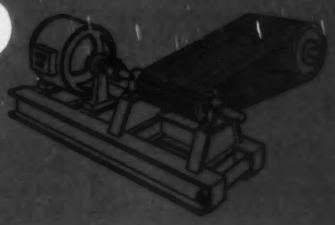

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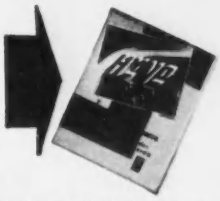

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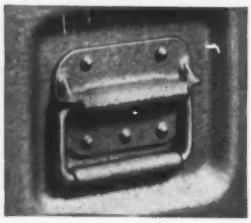

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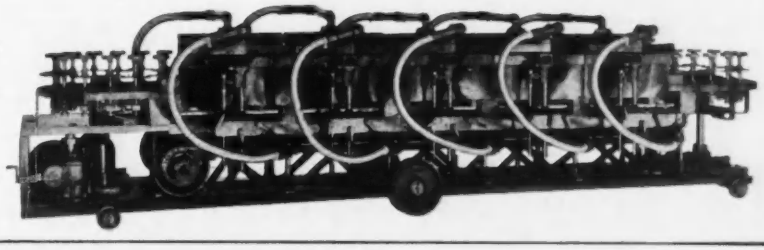

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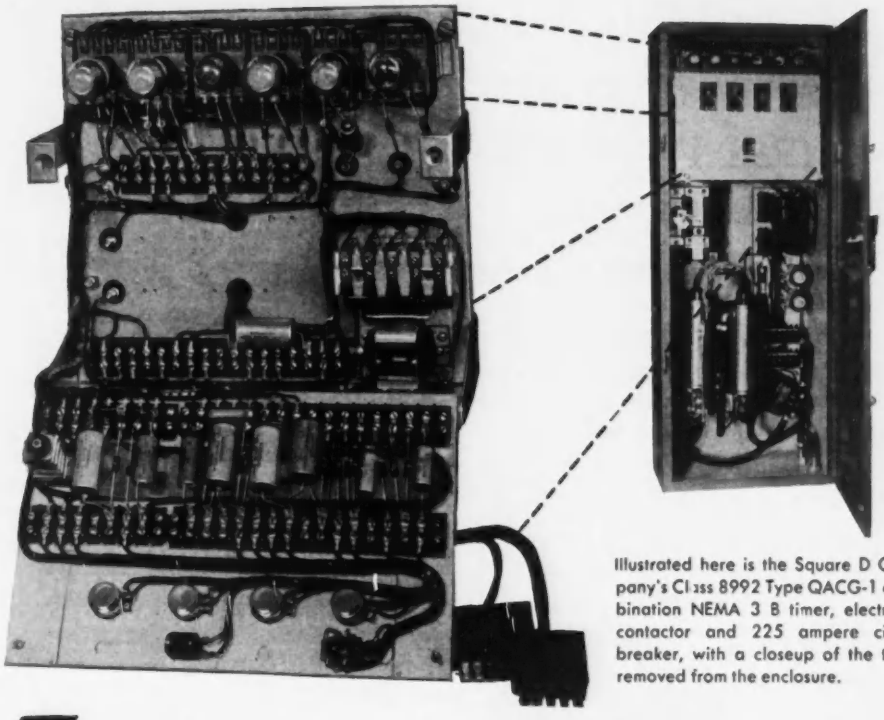

Illustrated here is the Square D Company's Class 8992 Type QACG-1 combination NEMA 3 B timer, electronic contactor and 225 ampere circuit breaker, with a closeup of the timer removed from the enclosure.

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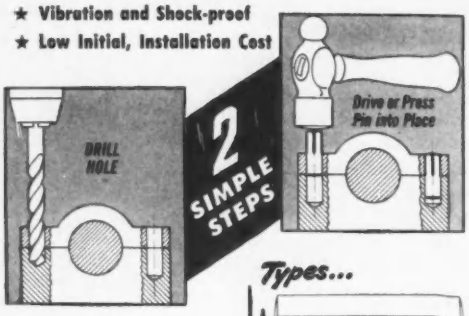
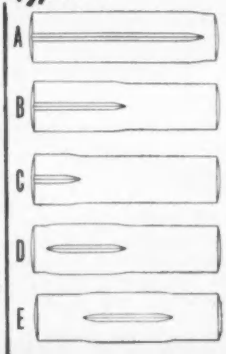


Types...



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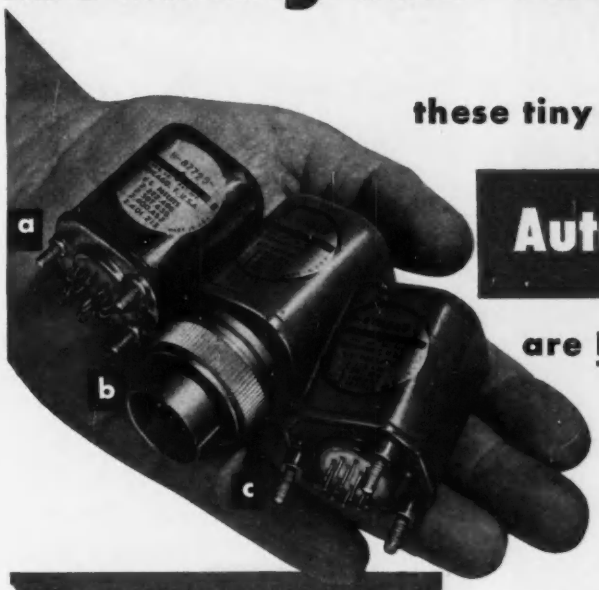

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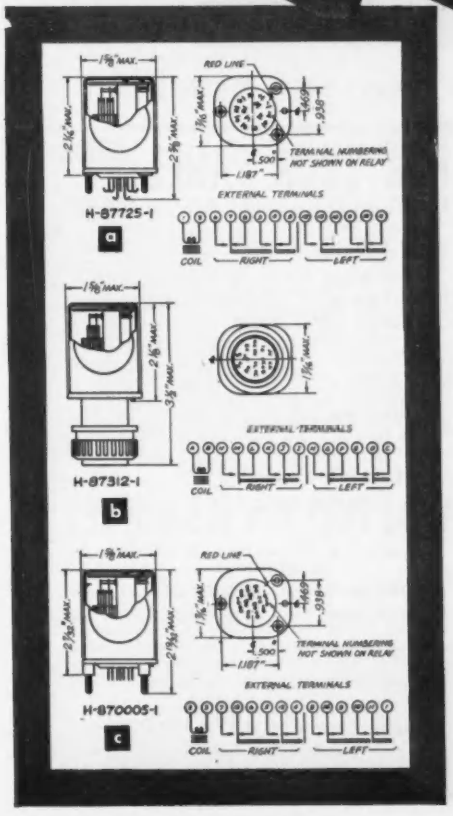

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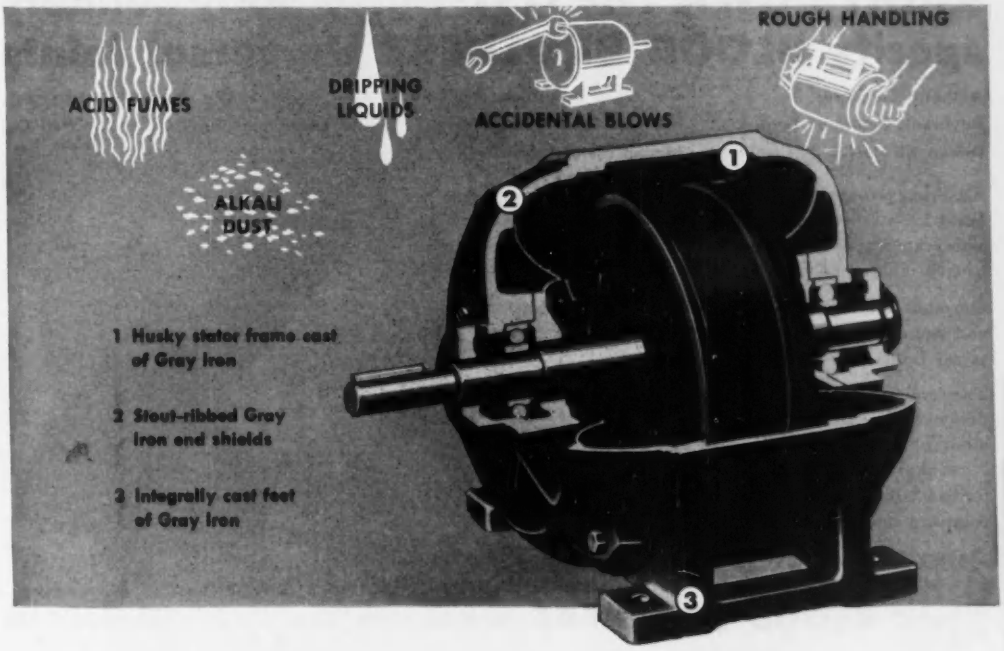

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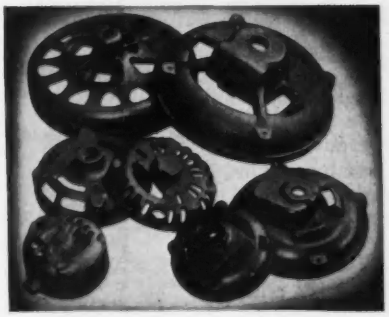

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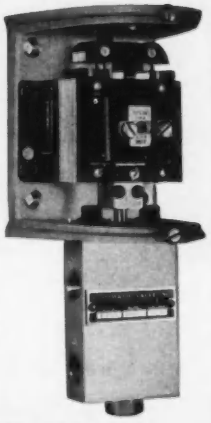

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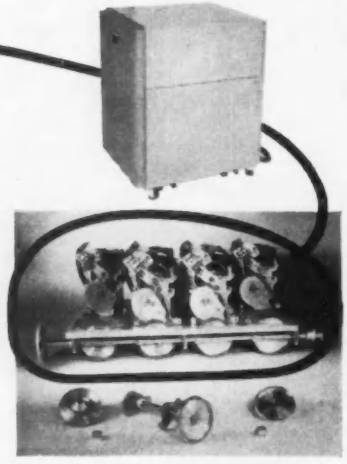

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SLEEVE BEARING DATA

Stock Sizes or Specials?

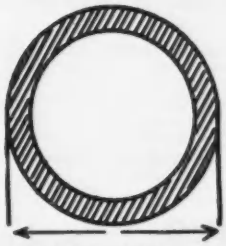
THE trend, in recent years, among leading designers of machinery and equipment is to use standard stock parts rather than specials wherever possible. And there is sound reasoning behind this move, particularly in cast bronze sleeve bearings.

Naturally in some instances it is essential to design and produce a special bearing for a specific application. Such factors as flanges, wall thickness, taper, special alloys and other characteristics that cannot be provided for in stock bearings can only be secured through special manufacturing operations. This often necessitates special patterns, tools, dies or other equipment not included in the cost of stock items. With the exception of long production runs of one size, special bearings are more costly than stock items.

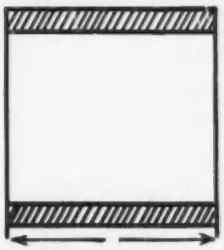
The factors that favor the designer in working to standard stock bearings are many. First, he has an unusually large range of sizes from which to make his choice. At the present we list over 850, comprised of 55 inside diameters, ranging from $\frac{1}{4}$ inch to $4\frac{1}{4}$; 55 outside diameters $\frac{3}{8}$ to $4\frac{1}{2}$; 46 lengths ranging from $\frac{3}{4}$ to $9\frac{3}{4}$. Thus it is possible to secure practically any size combination desired.

Standard stock bearings are cast in what is usually referred to as a general purpose alloy, providing better than average physical properties assuring long life and excellent performance. Oil grooves, slots, or holes are easily, quickly and economically added. Standard tolerances, as listed below, can easily be altered where closer precision is required or where greater clearance is necessary.

55 Inside Diameters



55 Outside Diameters



46 Lengths

Stock bearings are lower in cost, too, a very important feature in today's market. By making long runs of each size we are able to secure a low unit cost, which saving is passed on to the user. There is never any charge for patterns or tools. Complete stocks of all sizes are always maintained providing immediate delivery in any quantity. This eliminates the necessity for maintaining extensive inventory yet provides immediate service.

Engineering Service

It has always been the policy of the Johnson Bronze Company to work with customers in order to give them the greatest value for their money when purchasing bearings. In many cases we have found that a very slight change in bearing specifications or a slight alteration of a stock bearing will give the user the full benefits of this stock bearing service. We can also help you determine the correct type of bearing for each application. As we manufacture all types of Sleeve Bearings, we base all of our recommendations on facts, free from prejudice. Why not take full advantage of this free service?

●

This bearing data sheet is but one of a series. You can get the complete set by writing to—

CATALOGUE *—Lists and describes the most complete stock bronze sleeve bearing service on the market. Its more than 80 pages are filled with helpful bearing data. Write for free copy.*

Tolerances

Years of constant study of the bearing requirements of machinery builders have not only guided the selection of the sizes to stock as standard but have also governed the decision on the proper tolerances to standardize on. We find the following most acceptable:

Outside Diam. up to 3"	plus .002" to .003"
Outside Diam. above 3"	plus .003" to .005"
All Inside Diameters	plus or minus .001"
All Lengths	plus or minus .005"

Johnson Bronze

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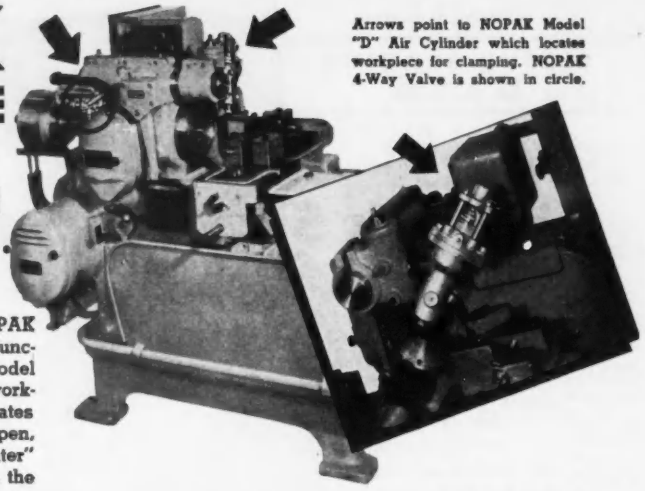
NOPAK
4-WAY VALVE Controls
Model "D" Cylinder and Air Operated Chuck on Sundstrand Lathe



Arrows point to NOPAK Model "D" Air Cylinder which locates workpiece for clamping. NOPAK 4-Way Valve is shown in circle.

In this lathe application, a ¼" NOPAK 4-Way Valve performs two vital functions. (1) It controls the NOPAK Model "D" Cylinder which locates the workpiece before clamping, and (2) it operates the air chuck. When the valve is open, the chuck is unclamped and the "locater" is down; when the valve is closed, the chuck is clamped and the "locater" is up.

This application of a NOPAK Valve and Cylinder is typical of many in the machine-tool field. It may suggest how you can use NOPAK products to improve the performance of machines or equipment you use in your plant, or build for others.

NOPAK ¼" 4-Way Hand Valve controls both air chuck and NOPAK Model "D" Air Cylinder.

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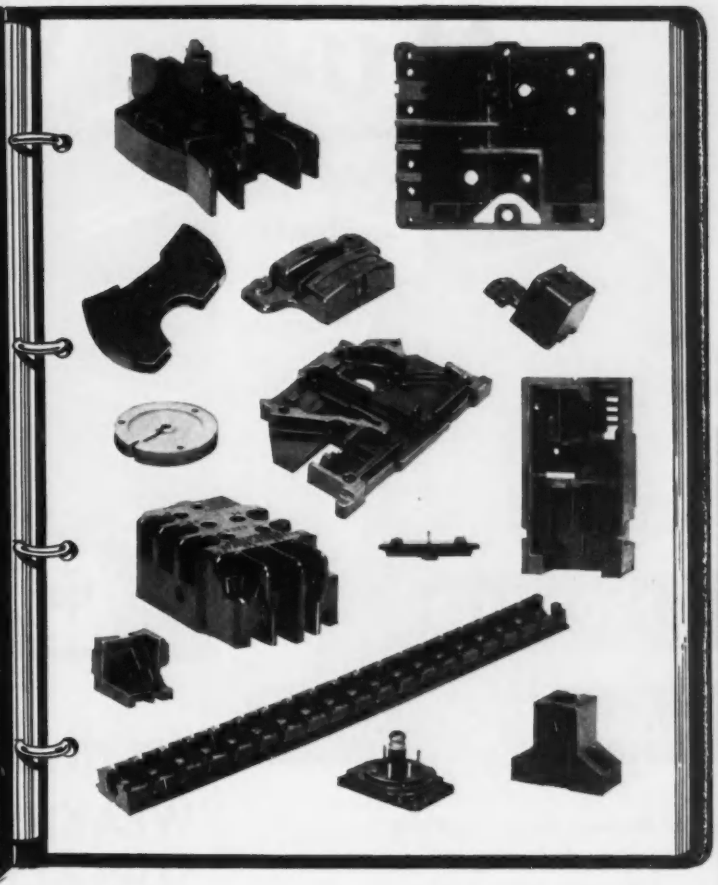

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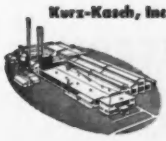

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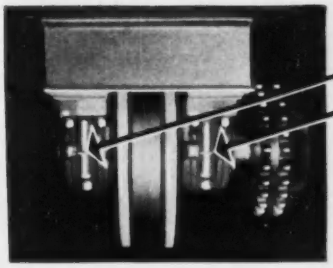

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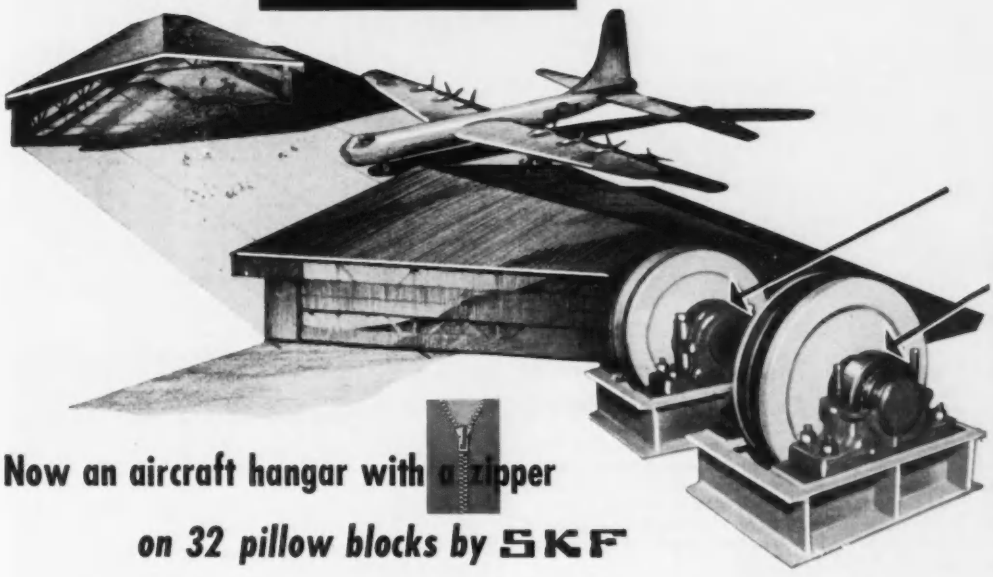

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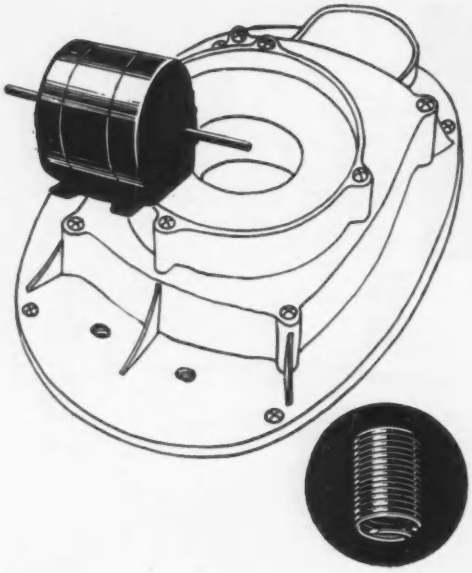

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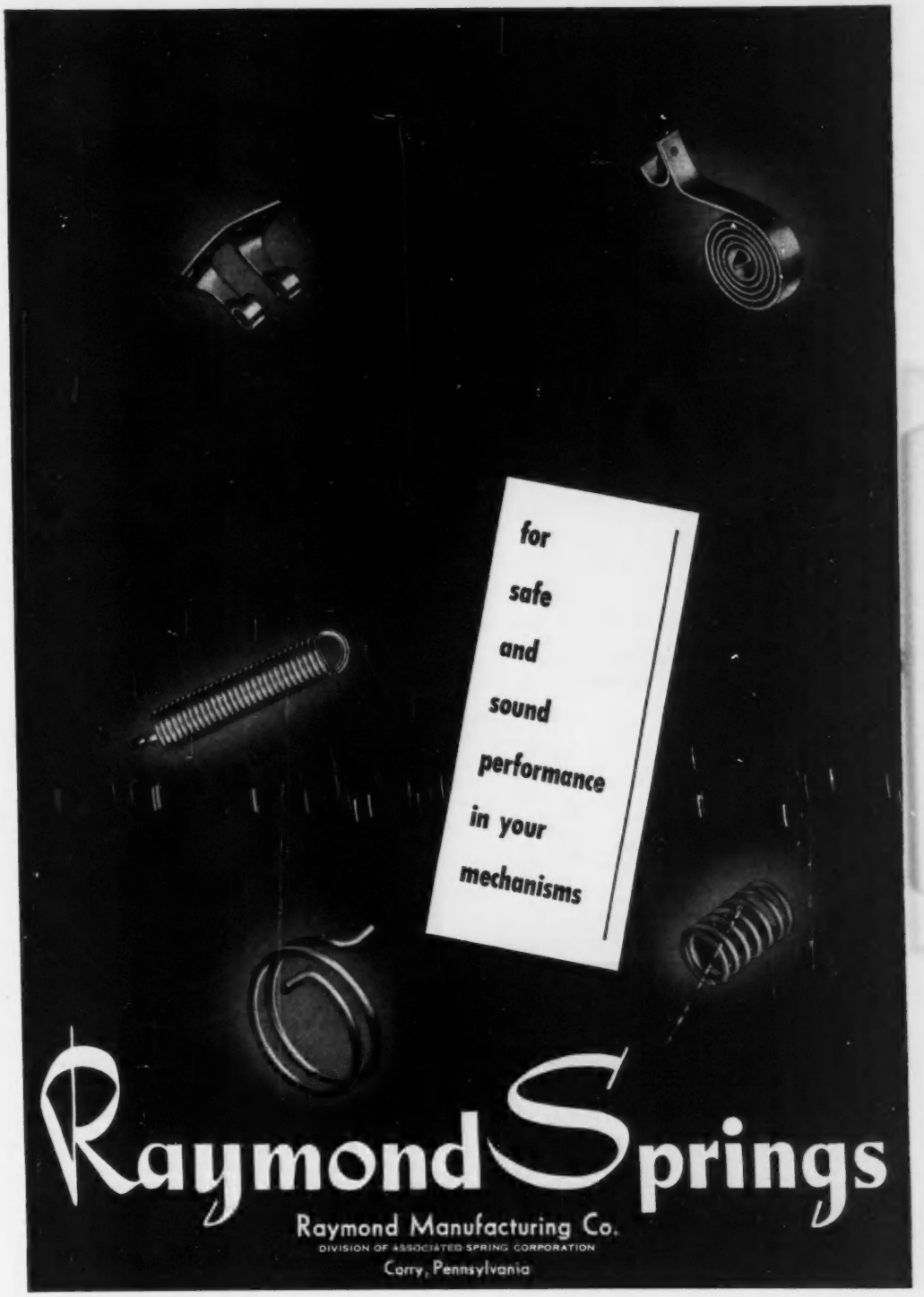
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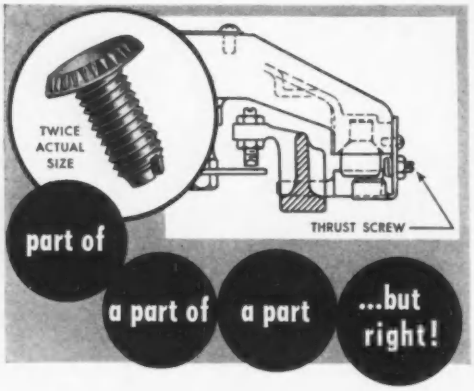

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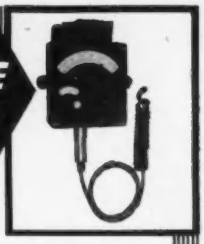

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Here's a handy reference that gives you a thorough analysis of the engineering, design, application, and maintenance principles you must take into account when working with rubber in industry. Whether you're an engineer—designer—shop superintendent—industrial technician—no matter what your link with the rubber field . . . you'll find this concise treatment of the physical and chemical properties of rubber compounds a handy and practical guide.

ENGINEERING WITH RUBBER

Edited by Walter E. Burton

In collaboration with engineers and research men of the B. F. Goodrich Company

461 pages, 445 illustrations, $6.50

THIS reference book gives you the practical engineering, application, maintenance and design principles of molded, extruded and lathe-cut rubber, hose, gaskets, belting, and scores of other rubber parts used by industry. It illustrates uses for American-made rubbers, crude and reclaimed rubbers and rubber-like materials . . . presents a complete picture of the physical and chemical properties of rubber compounds, the typical dimensions and structural details of industrial rubber products.

This guide shows you how to reduce vibrations with rubber mountings—how to determine when extruded rubber parts can be used—how to use packing and sheet rubber, etc. Its tremendous store of useful information is ready to help you find the right answers, the first time, to your specialized design and construction problems.

Stage-by-stage procedures show you how:

- to select and use rubber adhesives
- latex parts can improve product design
- to engineer and install V-belt drives
- to select rubber linings to withstand chemical action
- to design and install conveyor belt systems
- to work and use hard rubber
- to specify correct types of rubber hose for best service
- lathe-cut rubber can reduce costs

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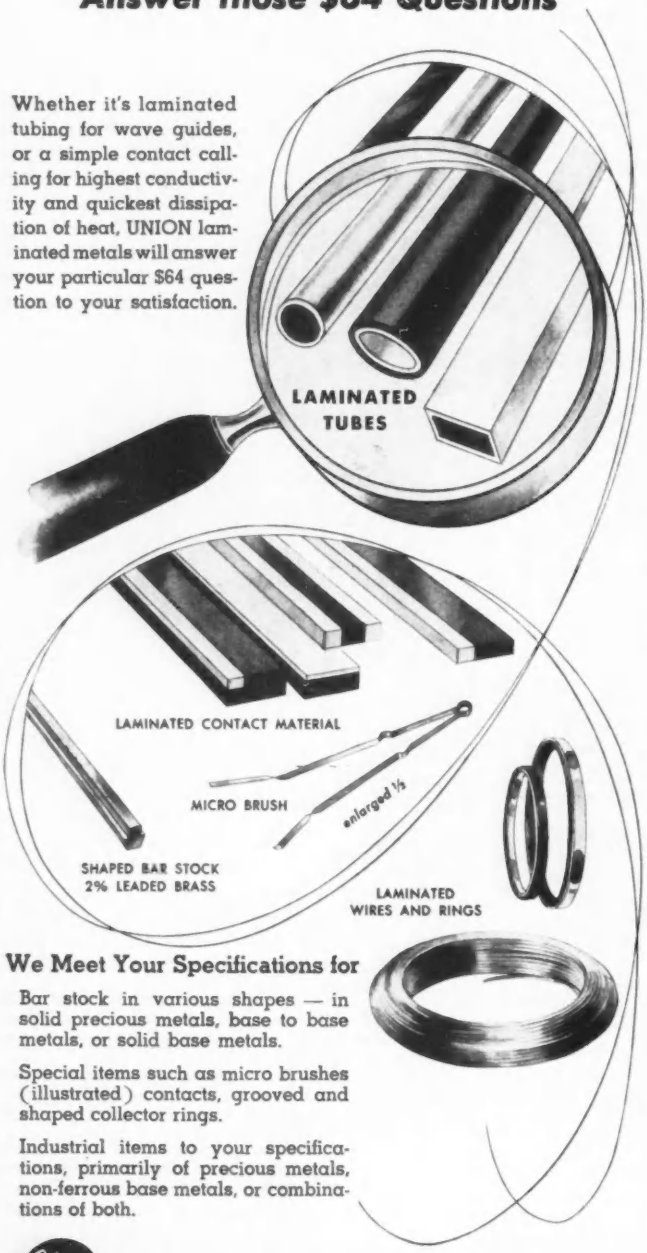

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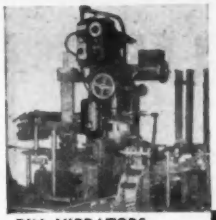

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VIBRATORY FEEDERS

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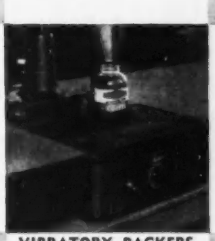
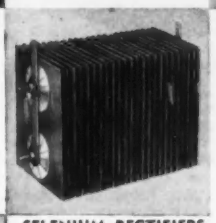


VIBRATORY PACKERS

PARTS FEEDERS

HOPPER LEVEL SWITCHES



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ELECTRIC VIBRATORS, promoting free-flowing bins, hoppers and chutes.

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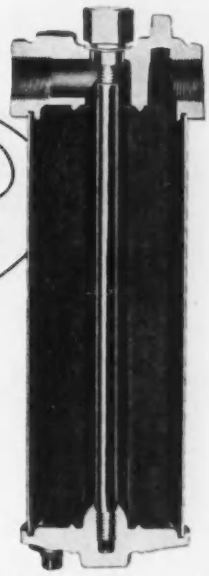
PRODUCT ENGINEERING

Keeps its Shape..

no matter how much it eats and drinks



Put the Cuno MICRO-KLEAN filter on almost any kind of a diet . . . and it will stay healthy longer than any micronic filter you know of.

Handling a wide range of fluids at a wide range of flow rates . . . the MICRO-KLEAN won't *shrink* or *swell* or *channel*. So there's no place for the fluid to go except where it's supposed to . . . through the cartridge.

Its dirt capacity is *double* that of any comparable filter—so its life is that much *longer*.

Finally, you can install it—inside or outside your equipment—with no trouble at all, because it takes up less space.

Check the box nearby for an explanation of MICRO-KLEAN's exclusive performance.

No Fluid Is Better Than Its Filtration

EXPLANATION

Why won't MICRO-KLEAN *shrink or swell or channel?*
Because the fiber structure is resinous-impregnated and polymerized, and resists any deteriorating effects of most fluids and contaminants.

Why does MICRO-KLEAN *have double dirt capacity?*
Because exclusive "graded density in depth" permits smaller particles to penetrate to varying depths—no surface-loading.

Why does MICRO-KLEAN *take up less space?*
Because the cartridge is *all filter*—no structural elements, no cans, bags, springs, inserts. Full-flow filtration needs much less room.

Also important: pressure drop is low . . . cartridge changing is easy . . . and CUNO MICRO-KLEAN *IS GUARANTEED TO REMOVE ALL SOLIDS LARGER THAN SPECIFIED . . . PLUS A LARGE PROPORTION DOWN TO 1 MICRON!*

Wide range of applications
Cuno MICRO-KLEAN filters come in varying densities (10, 25, 50 microns) . . . capacities from a few to more than 800 gpm . . . connections from ⅜ in. IPS to 6 in. flanged . . . single or multiple cartridge units.

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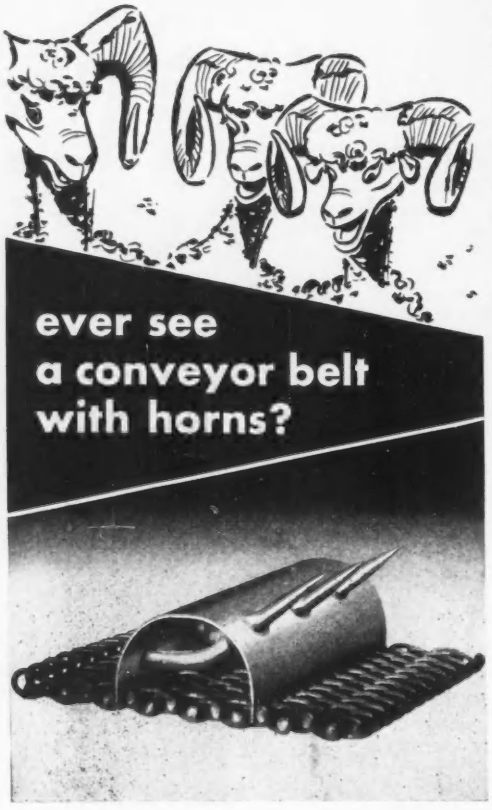

ever see
a conveyor belt
with horns?

Textile processors will recognize this unique belt as part of a Bale Breaker . . . the device that rips apart bales of raw fibre for processing. Heretofore, it has consisted of a series of steel spikes mounted on canvas belting. However, the spikes often strike stones, bits of metal or other foreign objects inside the bale, causing sparks that ignite flash fires that burn the belt itself.

Cambridge design engineers solved this problem by attaching metal spikes to a standard *woven wire* conveyor belt. Results: fewer fires because Monel metal spikes reduce sparking, no belt damage or repairs when fires do occur, water from sprinklers will not harm the belt, longer belt life from all-metal construction.

This is a typical example of the many unusual or difficult problems solved by the use of Cambridge woven wire conveyor belts. Cambridge belts can be constructed from any metal or alloy in a wide range of open or closed weaves. For any problem of combining product movement with processing through heat, cold or corrosive agents, rely on the experienced advice of your Cambridge Field Engineer. Write direct or see "Belting-Mechanical" in your Classified Telephone Directory.

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Engineering data on the design of ultrasonic systems

Considers the many uses of ultrasonics in industry

HERE is the first engineering consideration of the ultrasonic field . . . the essential theory, plus an abundance of practical information never before published! This important new book reviews electronic considerations and outlines of circuits. Mechanical and electrical design and construction techniques of ultrasonic systems are included . . . everything from the design considerations of holders for ultrasonic use to the experimental measurement of ultrasonic waves in various media.

ULTRASONICS

By Benson Carlin

Formerly, Product Research Supervisor, Sperry Products

244 pages • 162 Illustrations • $5.00

BOTH theoretical and practical, this book is definitely slanted toward engineering design and use in definite industrial applications. It brings you valuable information on: material testing, agitation, ultrasonic transducers, ultrasonic systems. It explains clearly the characteristics of ultrasonic waves that are important in practical applications: curves, waves, and complex waves; Fourier's theorem, wave trains and the law of angular transmission; the ways ultrasonic waves may be produced, and the electro-mechanical converting systems.

Evaluates Practical Uses in Many Fields

Brought out of the research laboratory and into industry, ultrasonics has tremendously broad, practical applications. This guide points the way to greater use of ultrasonics in, for example, MATERIALS TESTING: to detect flaws in metals, plastics and glass, etc.; CHEMICAL INDUSTRIES; to make better mixtures and emulsions, etc.; METALLURGY: for extremely uniform mixtures free of air bubbles, etc. It likewise discusses experimental applications to systems of television, underwater signaling, depth sounding, communication, destruction of bacteria, etc.

CONTENTS

1. Ultrasonic Waves
2. Ultrasonic Waves: Further Theory
3. Crystals for Ultrasonic Use
4. Crystal Holders for Ultrasonic Use
5. Resonance and Reflection
6. Continuous-wave Ultrasonic Systems
7. Pulsed Ultrasonic Systems
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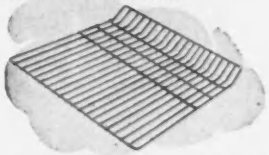
Problems Like These?

Short of Sheet Steel?



Try a Welded Wire Assembly!

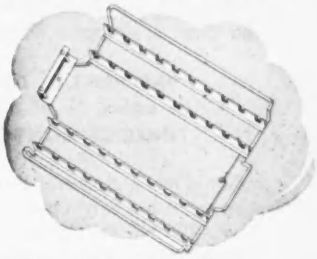
This Titchener-made tray for an ice cube machine replaces a stainless sheet steel piece. *Advantages: A better product.* Water now drains through — no longer overflows as it did with original stamping. *Lower cost.* Tooling was negligible, compared to expensive die required for the stamping. *Immediate availability.*

Using Expensive Castings?

Change to a Wire Form!

There's an increasing trend toward substitution of wire and wire-strip assemblies for castings, forgings and machined parts. This solder pot holder is an example. Stronger and lighter than a casting of like size, it is safe, unbreakable, far less costly.

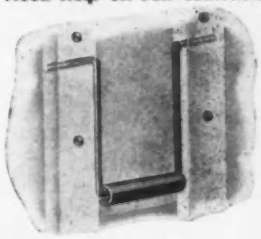
Want Fast, Expert Production?



Wire and Strip Assemblies— On Time!

Mass production of complicated designs is a Titchener specialty. This heating element rack requires 49 punched holes, 23 bends in heavy wire, 12 bends in strip steel and 22 spot welds — all punched, formed, assembled, welded in surprisingly fast time . . . and at minimum cost.

Need Help on Sub-Contracts?



Come to Wire Goods Headquarters!

For 65 years and through two World Wars, Titchener has worked closely with prime contractors in meeting government specifications on such parts as this ammunition box handle. Our experience with every conceivable type of wire and strip part can lick just about any problem you bring us.

TELL IT TO TITCHENER!

If your problem involves wire forms, welded-wire assemblies or wire-and-strip-steel items — Tell it to Titchener. Titchener offers you . . .

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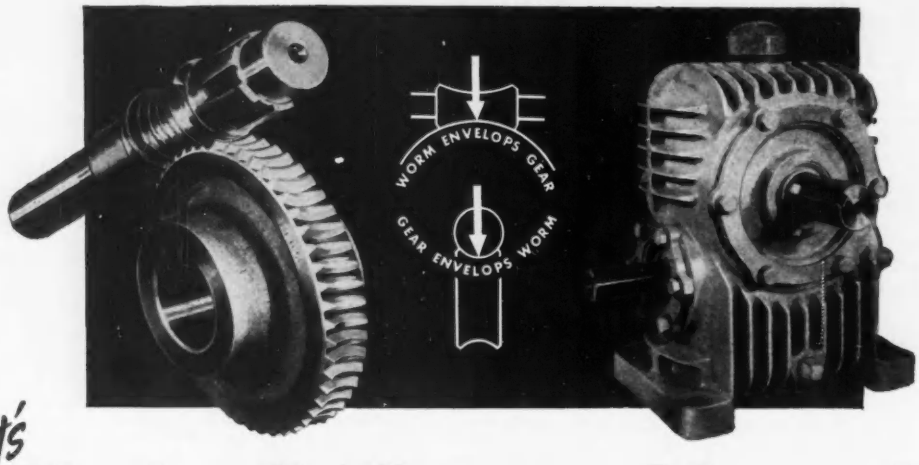

That's right—"hydraulically smooth" gears!

What we mean by "hydraulically smooth"

It used to be thought that carbide-tipped milling cutters on milling machines had to be protected against carbide-damaging gear vibrations in the cutter drive by using large flywheels at the cutter head. When Cone-Drive double-enveloping gears were tried, their 'hydraulic smoothness' made the flywheels unnecessary.

Never heard of gears that are hydraulically smooth? Then you should try Cone-Drive DOUBLE-ENVELOPING gearing: In Cone-Drive gears, the pinion or worm is wrapped around the gear and the gear is wrapped around the worm in such a manner that

regardless of number of teeth, gear size or ratio, ⅛ of all gear teeth are in CONTINUOUS CONTACT.

What is more, they are in continuous FULL DEPTH area contact. As a result, not only is power transmitted in a smooth uninterrupted flow AROUND THE CIRCUMFERENCE of the enveloped gear, but the load capacity for a gear set of any given center distance is greatly increased.

That means longer, trouble-free service, and the ability to use smaller gears to transmit a given load. As a matter of fact, Cone-Drive double-enveloping gears are so compact that many designers find they can simply

replace costly built-in gear trains with complete standardized Cone-Drive speed reducers

If you are looking for gears or reducers that will give you real hydraulic smoothness, greater load carrying capacity in a limited space, and a simpler gearing installation, fill in the coupon, attach to your company letterhead and mail it today.

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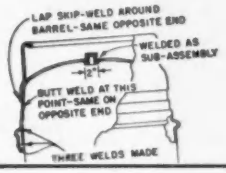
Ideas on Welded Design — For the Engineer's Notebook

MAKE WELDS DO DOUBLE DUTY

Relocation of a single weld can sometimes turn an impractical job into profitable production. For example, this slight design change simplified jigging and saved excessive fixture and equipment costs. An enlarged tap hole subassembly makes it possible to join chime ring, head, and center section with one mechanized HELIARC weld, made from inside the barrel. One complete welding operation is eliminated at each end of the barrel.

ORIGINAL DESIGN


LAP SKIP-WELD AROUND BARREL-SAME OPPOSITE END
WELDED AS SUB-ASSEMBLY
2"
BUTT WELD AT THIS POINT-SAME ON OPPOSITE END
THREE WELDS MADE

MODIFIED FOR PRODUCTION

FINAL WELD MADE AFTER INSPECTION
WELDED AS SUB-ASSEMBLY
WELD MADE FROM INSIDE OF BARREL THROUGH THIS OPENING-SAME ON OPPOSITE END
THREE WELDS MADE IN SUB-ASSEMBLY

Better Barrels at Lower Cost...

MINOR DESIGN CHANGE CUTS WELDING TIME . . . IMPROVES PRODUCT . . . SAVES THOUSANDS OF DOLLARS ON FIXTURES

To make these stainless steel barrels as first planned would have required several hundred thousand dollars' worth of special fixtures and new equipment. Redesigning as shown avoided most of this expense.

A single HELIARC weld, made from inside the barrel, now joins chime ring, head, and center section. Fixture requirements are vastly simplified: total amount of welding is less. And there's no cleanup problem. The smooth HELIARC welds are free from flux and spatter, with no "pockets" to harbor bacteria.

HELIARC welding is only one of many time- and moneysaving LINDE methods for fabricating metals. Whatever your metalworking problem, there's a good chance that LINDE know-how, show-how, and equipment can help you do the job better, more quickly, or at lower cost. Telephone or write our nearest office today. LINDE AIR PRODUCTS COMPANY, a Division of Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, N. Y. Offices in Other Principal Cities. In Canada: Dominion Oxygen Company, Limited, Toronto.

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Products and Processes for MAKING, CUTTING, JOINING, TREATING, AND FORMING METALS

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1001 USES IN THE ELECTRONICS INDUSTRY

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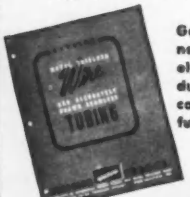
TAKES ANY SHAPE without losing its coaxial qualities.

ELIMINATES ELECTRO-STATIC PICK-UP, unwanted feed-back or spurious radiation.

NO INJURIOUS MOISTURE CONDENSATION caused by temperature changes or humidity.

PROTECTION AGAINST CORROSION, abrasion, acids, etc. afforded by solid shield.

AVAILABLE IN MANY METALS—aluminum, copper, brass or nickel.



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By William H. Schutt
Wm. H. Schutt Associates, Detroit

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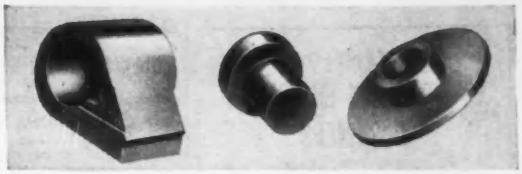

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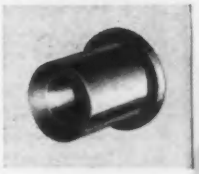

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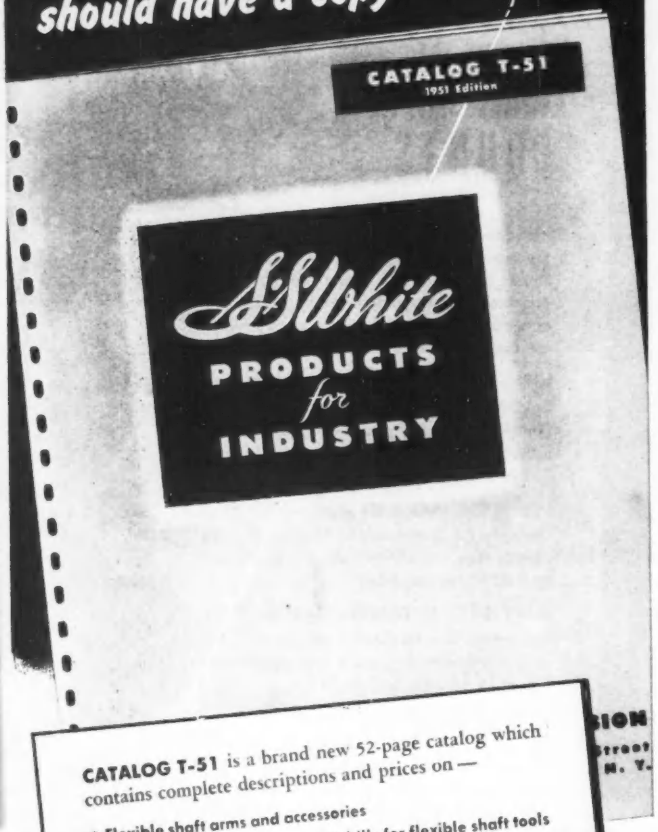

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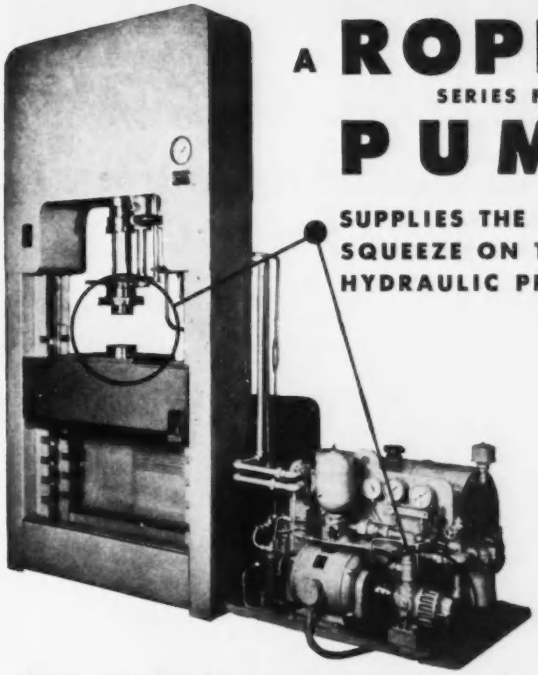

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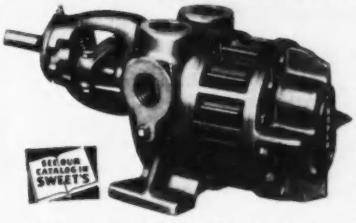

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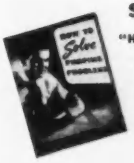

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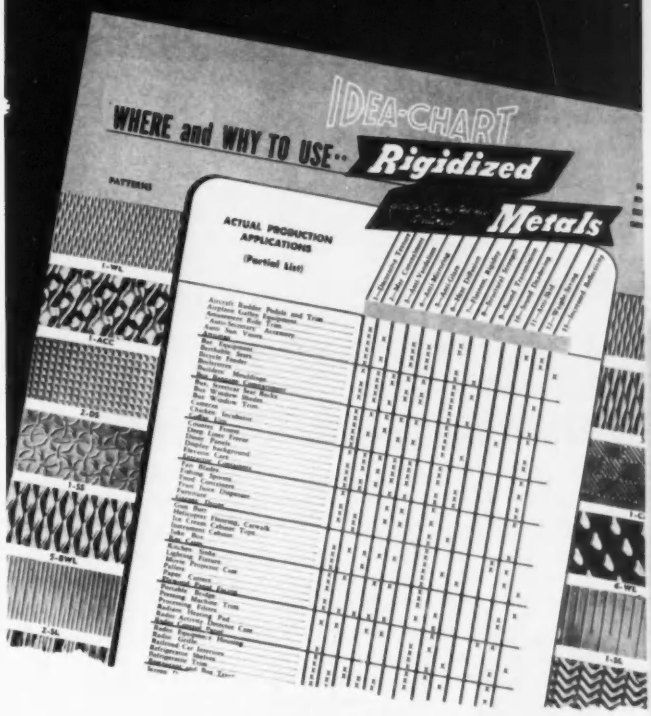
Let the experience of others who have used RIGIDIZED METALS guide you in your choice of patterns



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Rigidizing is a patented process for applying to metals a clear-through, textured pattern that strengthens and beautifies the metal.

The people who have used Rigidized Metals made up this chart for you. They told us what they used them for and the definite benefits they gave. A copy is yours for the asking.

Rigidized Metals are made in 18 attractive patterns. Ferrous or non-ferrous metals in sheet or strip, coils or cut lengths, solid or perforated.

U. S. and Foreign Patents

Rigidized Metals Corporation

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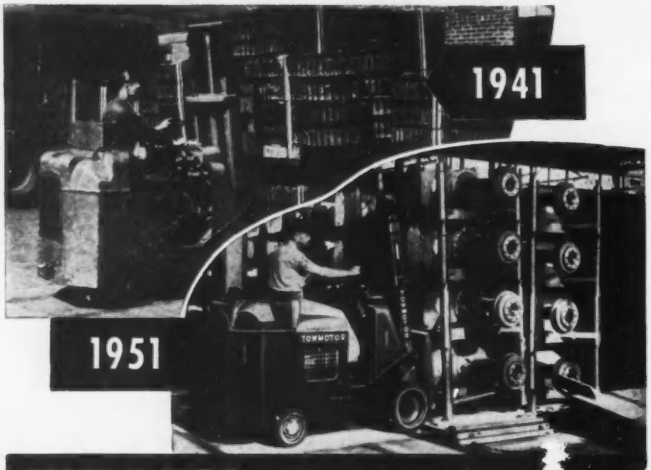
Sales Offices in Principal Cities



HYDRECO OIL HYDRAULIC PUMPS • VALVES • CYLINDERS

once again help speed American Defense

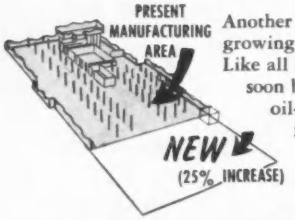
When America was The Arsenal of Democracy, HYDRECO-equipped hydraulic lift trucks like the Towmotor pictured above, helped to revolutionize material handling in the new defense industries.

Now once again, HYDRECO-equipped industrial lift trucks, such as this '51 Model LT40 Towmotor, are "mass-handling" industrial products to help speed American defense.

A 1500 Series HYDRECO gear pump, designed to operate at full engine speed, is directly coupled to the Towmotor engine to provide always-ready hydraulic power.

HYDRECO Hollow-Plunger control valves are used on these Towmotor trucks to cut out lost motion in picking up and stacking, as HYDRECO valves provide smooth and accurate control in raising, tilting, and accessory operations.

On the LT40 Towmotor, both tilt and lift cylinders are also HYDRECO-built. Designed for operation under all conditions, efficient wipers and cylinder packing *keep oil in and dirt out* of the hydraulic system.



Another new addition to HYDRECO's fast-growing plant is scheduled for completion soon. Like all HYDRECO facilities, this addition will soon be devoted entirely to the production of oil-hydraulic pumps, valves and cylinders for the materials handling, earth moving, road building and other equipment industries.

HYDRAULIC EQUIPMENT COMPANY

1112 EAST 222nd STREET • CLEVELAND 17, OHIO

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SOLVED:

How to keep pace with growing demands in Leather and Synthetic Rubber PACKINGS

At G&K-INTERNATIONAL our laboratory, engineering and production staffs have pioneered many developments in mechanical packings, and today are tackling the toughest problems with *experience.*

Co-ordination is the reason for our plus-average in coming up with the right answer.

And because packings problems too often come up when time is critical. you'll benefit by consulting us *now* regarding packings in your business.

For PACKINGS in Grakone (Synthetic) and Leather

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INTERNATIONAL PACKINGS CORPORATION

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GRATON & KNIGHT COMPANY

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GRATON AND KNIGHT

Since 1851

BREATH OF LIFE SEALED IN WITH RUBATEX

After trying numerous gasketing materials, Air Shields, Inc., of Hatboro, Pa., has selected RUBATEX G-200 for its Isolette Infant Incubator. With only the weight of the plexiglass cover to provide pressure, RUBATEX forms a completely airtight seal—thus safeguarding the precious balance of oxygen and filtered air within the incubator.

RUBATEX is ideal for important gasketing applications. It has uniform resiliency and excellent compressive strength. In addition, its unique closed cell structure is non-porous and cannot absorb moisture. RUBATEX is rot and vermin proof and resists oxidation. Most gasket requirements can be economically cut from sheet stock. Even the expense of a molded-on skin is unnecessary.

RUBATEX has many uses in addition to gasketing—absorbing shock, damping vibration and as a packing material. It is available in natural and synthetic stocks in soft, medium and firm forms. Our engineering staff will gladly advise you on the type of RUBATEX best suited to your job. Write for Catalog RBS-12-49, Great American Industries, Inc., RUBATEX DIVISION, BEDFORD, VIRGINIA.

Dropped from a height of more than one hundred feet, this egg bounced off a three-inch-thick pad of RUBATEX closed cellular rubber without breaking. RUBATEX absorbed and dissipated the impact shock equal to a velocity of more than sixty miles an hour.

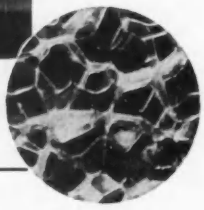

Photo-micrograph of RUBATEX closed cellular rubber shows the tiny individually sealed balloon-like chambers which retain inert nitrogen under pressure.

RUBATEX®

CLOSED CELL RUBBER

FOR GASKETING • CUSHIONING • SHOCK ABSORBING • VIBRATION DAMPING

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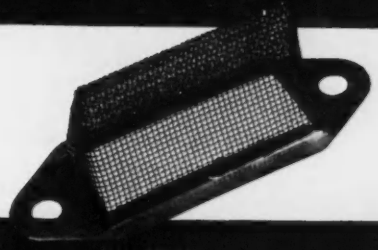
NEWARK
Fabricated
WIRE CLOTH PARTS

Available — a well-equipped plant with highly experienced fabricators.



Available — mesh cloth and space cloth made in our own plant.

All under one roof

Do you require parts made with one or more pieces of mesh cloth or space cloth — anything from 4 inch openings down to 325 mesh (105,625 holes/sq. in.)?

Our experienced fabricating service should be of value. We are in position to handle volume order business and, if desired, will be glad to help in designing the part requiring the metallic cloth. We know how to insert and fasten metallic cloth to get best results. We carry many standard sizes of wire cloth in stock. We have ample loom facilities to weave special cloths if necessary. We can handle any wire of any malleable metal.

This fabricated parts division of our business has grown by leaps and bounds. We have had many repeat orders. It could be due to the quality of wire cloth used and the care with which this cloth is assembled into the parts being fabricated.

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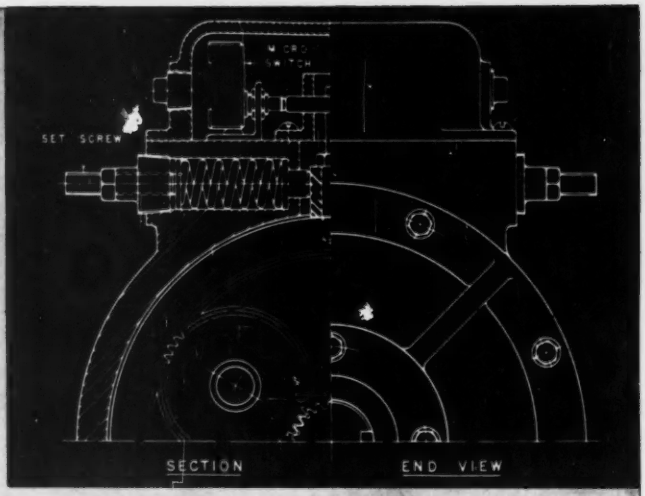
Positive Protection from OVERLOAD DAMAGE



PHILADELPHIA PLANETORQUE MOTOREDUCER

CUTS OFF MOTOR CURRENT INSTANTLY AND AUTOMATICALLY

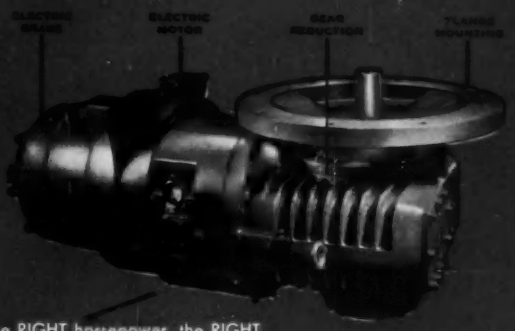
. . . when the load reaches a predetermined value, thus protecting both the driven machinery and the drive unit from overloads. This feature can be provided on any MotoReduceR . . . either vertical or horizontal types. On removal of the excessive load the PlaneTorque MotoReduceR may be started without resetting the switch. Incidentally, the PlaneTorque can be cut out during the starting period, by merely holding down the starting button; upon release PlaneTorque is again operative. The PlaneTorque is ideal for Stoker drives, Conveyors, Crushers, Mixers, Rolls, Pulverizers and a "hundred and one" other machines. MotoReduceRs are available in all required Horsepowers and Reduction Ratios. Efficiencies are as high as 97%.

For full information about Philadelphia MotoReduceRs and the PlaneTorque feature, send for Bulletin MR49. Please write on your Business Letterhead.

Philadelphia Gear Works, INC.

ERIE AVE. AND G ST., PHILADELPHIA 34, PA.
NEW YORK • PITTSBURGH • CHICAGO • HOUSTON
IN CANADA: WILLIAM AND J. G. GREEY LIMITED, TORONTO

Industrial Gears and Speed Reducers
LimiTorque Valve Controls



You can't beat the combination of the RIGHT horsepower, the RIGHT shaft speed, the RIGHT features all in one compact unit that you can use RIGHT where you want it. It's the best way and the easiest way to select your power drives because you purchase one unit, handle one unit in your receiving, production, or maintenance departments . . . set one unit in place and you're ready to go.

Master Motors, available in thousands and thousands of types and ratings (up to 150 HP) give you an enormous selection of integrally built power drives from which you can easily select the combination of features that's just right for each job.

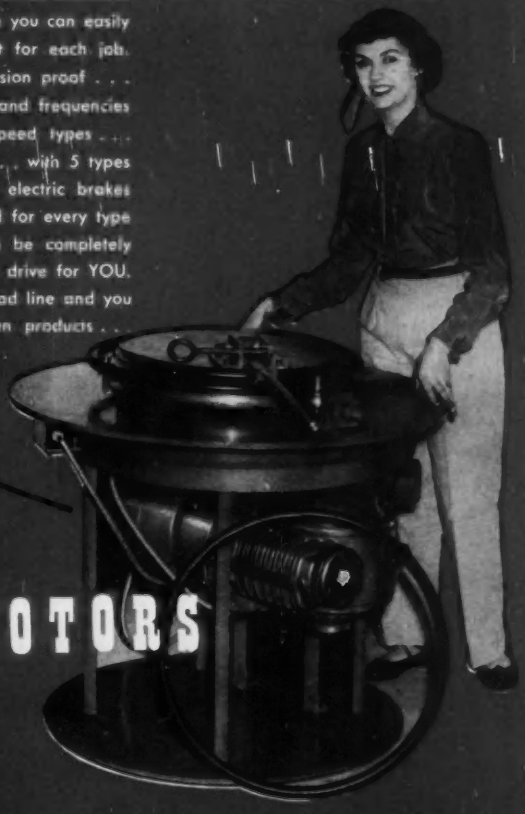
it's so easy to do it

RIGHT

Open, enclosed, splash proof, fan-cooled, explosion proof . . . horizontal or vertical . . . for all phases, voltages and frequencies . . . in single speed, multi-speed and variable speed types . . . with or without flanges or other special features . . . with 5 types of gear reduction up to 432 to 1 ratio . . . with electric brakes . . . with mechanical variable speed units . . . and for every type of mounting . . . Master has them all and so can be completely impartial in helping you select the one best motor drive for YOU.

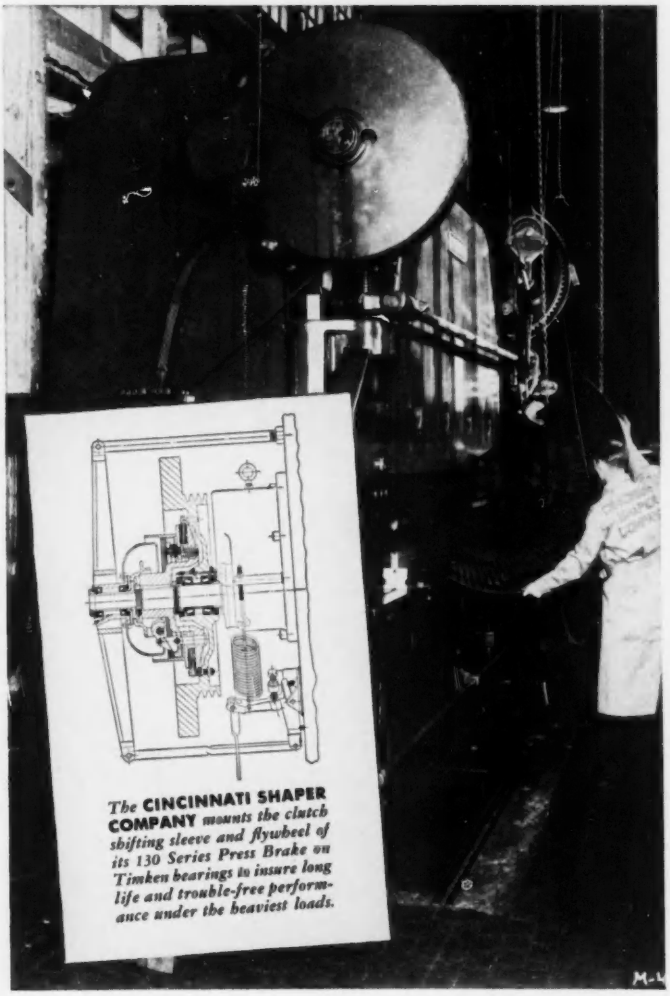
Select the RIGHT power drive from Master's broad line and you can increase the saleability of your motor driven products . . improve the economy and productivity of your plant equipment.

THE MASTER ELECTRIC COMPANY
DAYTON 1, OHIO



MASTER GEARMOTORS

Pressing problem solved by TIMKEN® bearings



The **CINCINNATI SHAPER COMPANY** *mounts the clutch shifting sleeve and flywheel of its 130 Series Press Brake on Timken bearings to insure long life and trouble-free performance under the heaviest loads.*

TO take the heavy load of forming metal, the bearings in this 130 Series Press Brake, built by the Cincinnati Shaper Company, have to be rugged, long wearing and practically friction-free. That's why you'll find Timken® tapered roller bearings in the flywheel and clutch shifting sleeve. Timken bearings at these critical parts assure minimum maintenance, virtually friction-free operation, and trouble-free service even under the heaviest loads.

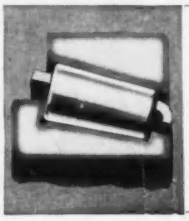
Line contact between rollers and races gives Timken bearings extra load-carrying capacity. Tapered construction enables them to take any combination of radial and thrust loads. They are made of tough, wear-resistant Timken steel and manufactured to extreme precision.

As a result, the flywheel rotates freely, the clutch sleeve can absorb tremendous loads, stays in perfect alignment. And Timken bearings reduce friction to a minimum because of an incredibly smooth surface finish and true rolling motion.

With Timken bearings on the job, lubrication time and maintenance costs are minimized. Wear on moving parts is reduced. Breakdowns are prevented. Under normal conditions, Timkens bearings last the life of the machine.

It pays to have Timken bearings on every wheel and shaft of your machinery. No other bearing can give you *all* the advantages of Timken bearings. Always look for the trademark "Timken". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



GREATER LOAD AREA

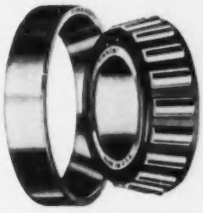
Because the load is carried on the *line* of contact between rollers and races, Timken bearings carry greater loads, hold shafts in line, wear longer.

The Timken Roller Bearing Company is the acknowledged leader in: 1. advanced design; 2. precision manufacturing; 3. rigid quality control; 4. special analysis steels.

TIMKEN

TRADE-MARK REG. U.S. PAT. OFF.

TAPERED ROLLER BEARINGS



NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◫ AND THRUST →◫← LOADS OR ANY COMBINATION ✳